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Fig. 1—Car ignition systems radiate interference which distorts television pictures. By properly designing or suppressing the ignition system, the SAE Vehicle Radio Interference Subcommittee found, it is possible to reduce this effect to tolerable limits

Television Brings Change In Car Ignition Behavior

BASED ON PAPER* BY **P. J. Kent,** Chief Engineer,
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ACCELERATED growth of television and FM communication services emphasizes the importance of methods recently devised to prevent motor vehicle ignition systems from transmitting radiation interference, like that in Fig. 1, to television screens. Developed by the SAE Vehicle Radio Interference Subcommittee, these radiation suppression methods offer subsidiary benefits such as longer spark-plug life and perhaps greater fuel economy.

High frequency communication and television services—subject to interference, at a distance, from vehicle electrical system radiation—is expanding rapidly. While presently concentrated in metropolitan areas, these services will quickly move into smaller towns and suburban areas.

The new postwar radio spectrum—from 25,000 to 30,000 megacycles—brought changes and expansions

in radio services and also added new types. Manufacture of both television and FM-AM receiving sets mushroomed within the last year. Television set production during the first quarter of 1948 was 118,027, nearly three times that for the same period of 1947. And the 437,829 FM-AM sets produced the first quarter of 1948 represents a similar gain over 1947 output of these units.

Fig. 2, showing presently installed and planned coaxial cable and radio relay systems to be put in operation by the Bell System, further testifies to fast-stepping activity in this field.

Radio manufacturers, anticipating this expansion, became aware of how serious automotive radiation might become in the derivation of satisfaction from FM and television sets. A joint SAE-Radio Manufacturers Association committee was set up in 1944 to study the problem. Purpose of the group was to find a tolerable level of interference and to devise means for eliminating vehicle interference or at least reducing it to this tolerable level.

Tests at Rye, New York, in 1944 tentatively established the tolerable radiation as 35 microvolts per meter radiation field strength at a distance of 50 ft from the extreme side of the vehicle. These tests also showed that television probably is more sus-

How Car Electrical Systems Radiate Video Interference

While we think of the electrical system of the motor vehicle as dealing with low voltage direct currents, nevertheless there are several points in the electrical system where high frequency oscillating currents exist. At any point where an arc is created, there will always be a transient oscillating current flowing in certain localized sections of the vehicle wiring. Such arcs will occur under certain conditions at the brushes of the generator, the starting motor, or any other motors such as those which operate the heater fan. Such arcs may occur at the breaker points of any of the numerous relay devices, such as the voltage regulator.

In the ignition system, even though an actual arc does not occur at the breaker points, there will be a high frequency oscillation in the primary circuit when the points open. Most important of all, however, is the extremely high frequency oscillation which occurs in the secondary circuit when the spark occurs at the spark plug gap.

Except in the case of the ignition high tension circuit, the transient oscillating currents are of relatively low frequency and value, consequently, of less importance in setting up electromagnetic wave propagation in the radiation field. But they are of considerable importance in creating disturbances within the limits of the induction field. These disturbances are of primary importance in creating interference within a radio set which is installed in the same vehicle with the electrical system. They also have an effect at very short distances from the vehicle and are of minor importance when considering the interference to radio sets in other vehicles which may operate in close proximity to the vehicle causing the disturbance.

When the breaker points in the primary circuit of the ignition system open, there is a rapid change of current in the primary circuit, this causes a rapid change in the magnetic flux which links between the primary circuit and the secondary circuit of the ignition coil. As the magnetic flux collapses through the secondary winding, it induces a very high voltage in the secondary circuit, that ionizes the gases between the electrodes of the spark plug, causing a spark to occur.

The secondary discharge has a capacity component of extremely short duration, probably not exceeding one-millionth of a second. It has been calculated that the peak value of the current during the interval of the capacity discharge may equal as much as 150 amp. The discharge of the capacity component also oscillates at very high frequency. Following the short-duration capacity component is the induction component of longer duration and much lower current value. The current decreases exponentially in this period and sine wave oscillations are superimposed on it. Frequency of these oscillations depends upon the characteristic frequency of the primary circuit.

It is the extremely high-frequency, high-current discharge in the capacity component of the spark which causes electromagnetic waves to radiate outward from the high-tension ignition system. Quantitative and qualitative tests of this radiation would indicate that it does not occur at any fixed frequency, but at a great many different frequencies, and the magnitude of the radiation will vary greatly at different frequencies.

Largely because the frequencies at which the electromagnetic waves (radiated by the ignition system) coincide with the frequency of the carrier waves utilized in radio and television broadcasting are we faced with the problem of radio and television interference.

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ceptible to electrical interference than any other radio communication system; thus adequate suppression to protect television automatically would take care of the other services.

Fortified with this tolerable radiation limit, the SAE Vehicle Radio Interference Committee went to work to determine how best to achieve suppression.

Three series of field tests conducted by the SAE group disclosed facts about ignition system design and suppression methods related to radiation suppression that eventually led to recommendations to the Automobile Manufacturers Association.

For example, field test results showed that cars with compactly grouped ignition-system components produce less interference than those having components more widely distributed. Radiation from any given car varied over wide limits at different frequencies tested.

These investigators also found that radio resistors at the spark plugs and distributor center tower were more effective below 40 megacycles than above; but even in the higher frequency range, these resistors reduced radiation to much less than the unsuppressed value. A very effective method of suppressing radiation was found to be the complete enclosure of the ignition system in a grounded metallic shield with suppressors at the spark plug and distributor center tower; however, this was considered probably more than necessary for satisfactory radio and television reception.

Most cars satisfactorily met the tentative tolerable value (35 microvolts per meter at 50 ft) with 10,000-ohm suppressors at each spark plug and in the distributor center lead, with the ignition coil so located so as to keep the coil-to-distributor high tension lead not over 8 in. long. Test results pointed up the advisibility of keeping all rods, metal tubing, conducting tubing (such as coolant lines), and wiring other than ignition away from the ignition system.

No excessive interference was noted from electrical equipment other than ignition at the 50-ft distance, although it was felt that on some vehicles such interference might exist.

With these and other radiation revelations providing the groundwork, the SAE Subcommittee reported to the Automobile Manufacturers Association that most vehicles could be suppressed to come within tolerable limits of radiation by the following provisions:

1. Use of 10,000-ohm suppressors at each spark plug.

2. Use of a 10,000-ohm suppressor in the distributor-to-coil high tension lead.

3. Locating the high tension coil so that the high tension lead from coil to distributor is not over 8 in. long.

4. Keeping the primary electrical wiring, metal rods, and conducting tubing as far as possible from the high tension wires.

Next job tackled by the SAE group was study of the effects of radio interference suppression on engine performance.

While investigating detrimental effects of suppression on the engine, it was found that suppressors did not effect gasoline economy of either a 6-cyl, 218-cu in. engine or an 8-cyl, 324-cu in. engine tested. Tests also were run under cold-temperature starting conditions, with reduced voltage applied to the primary of the ignition circuit—with and without spark-plug suppressors—and with different types of ignition coils. No difference in cold starting results was found that was in any way related to the amount of energy in the spark. So long as the secondary voltage was sufficient to fire the gap at the spark plug, nothing else in the characteristic of the spark seemed to have any bearing on its ability to start the engine.

An unexpected advantage found with suppressor-equipped spark plugs (using either external or built-in suppressors) is that gap growth is considerably less than with the same type of plug minus suppressor. Tests on several different engines running continuously at wide-open throttle at various speeds, reveal that rate of gap growth in spark plugs with 10,000-ohm suppressors is about one-half that experienced with standard plugs.

This opens up the possibility of using higher initial gaps while still getting as good, or better, life from the plugs up to the time when gaps have to be adjusted.

Many investigators find they can get a smoother idle and better low-speed, light-load operation by increasing the spark-plug gap. Another interesting possibility is to change the characteristics of the ignition coil so that it will produce a higher secondary voltage without increasing the energy in the spark. Still another gain possible, by making these changes in the electrical system, is the successful use of leaner mixtures, improving gasoline economy under low-speed, road-load conditions.

Present Status of Suppression

Most motor vehicle manufacturers have altered their vehicles as of Jan. 1, 1948, as regards built-in changes to the electrical system. Some of these will meet the tentative tolerable value of radiation without further changes. Many other vehicles will have to be provided with additional suppression—with suppressors at the distributor center lead, at the spark plugs, or both.

Of course the big problem is suppression of all vehicles now in service. Those cars equipped with radios and suppressed for operation of these sets are largely freed of the reduced radiation problem at a distance. It is hoped that owners of older cars, not equipped with radios, may become owners of home FM or television sets and thus have some incentive to suppress their vehicles.

But if new vehicles are suppressed, seriousness of the problem will rapidly diminish. Prewar cars, kept in service because of wartime curtailment of automobile production, will be replaced by new ones so that in the not-too-distant future, a very high percentage of vehicles on the road will be suppressed.

Fig. 2—Bell System coaxial cable and radio relay routes both under construction and being planned

BASED ON PAPER* BY

R. J. S. Pigott

Chief Engineer
Gulf Research & Development Co.

Fitting the Supercharger
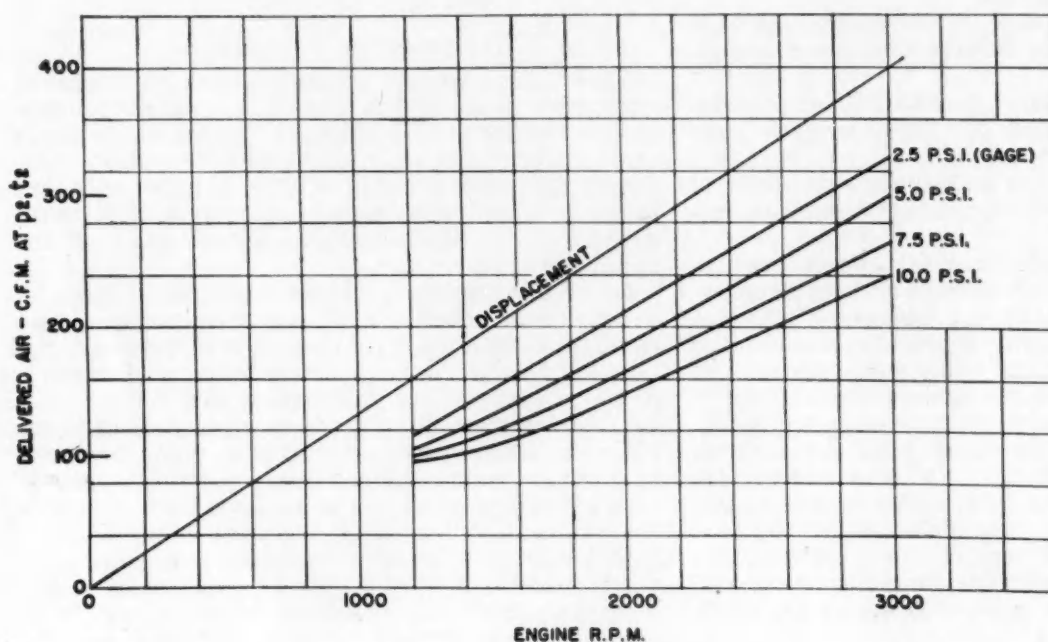
Fig. 1—Air delivery at delivery conditions as a function of supercharger rpm for various boost pressures

2.5 P.S.I. (GAGE)

5.0 P.S.I.

7.5 P.S.I.

10.0 P.S.I.

DISPLACEMENT

DELIVERED AIR — C.F.M. AT p_2, t_2

ENGINE R.P.M.

Fig. 2—Delivery temperature as a function of supercharger rpm for various boost pressures

10.0 P.S.I. (GAGE)

7.5 P.S.I.

5.0 P.S.I.

2.5 P.S.I.

DELIVERY TEMPERATURE — °F.

ENGINE R.P.M.

20
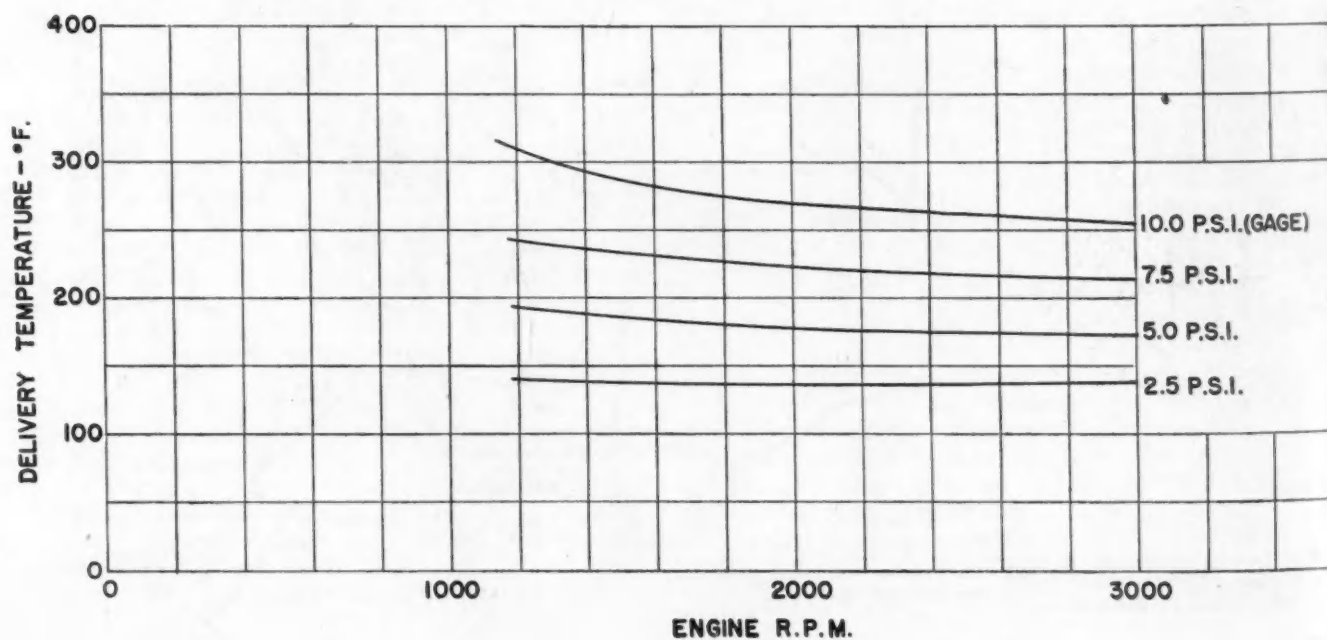
Positive-Displacement
To the Engine

(This paper will be printed in full in **SAE Quarterly Transactions**)

FOR a supercharger to fit an engine, the supercharger must satisfy the engine's demand for air at design boost and engine rpm. Whether or not the supercharger fits the engine and what the supercharged performance will be at full throttle at any speed can be determined by analysis, without trying out the supercharger in an expensive engine test setup.

If the supercharger delivered the same volume of

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* Paper "The Supercharger and the Engine" was presented at SAE Central Illinois Section on March 10, 1948, Canadian Section on March 17, 1948, Mohawk-Hudson Section on April 20, 1948, and Cincinnati Section on May 18, 1948. (Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

air per revolution and the engine demanded the same volume per revolution at any number of revolutions per minute, deciding the question of fit and estimating performance would be simple. But the engine and supercharger are two displacement devices whose volumetric efficiencies vary quite differently with speed and boost pressure. Volumetric efficiency of the supercharger increases with speed. That of the engine decreases with speed.

Understanding these volumetric characteristics of the two devices makes it possible to determine whether their volumes match at the design point and what performance can be expected from the combination at other points.

For either device, there are two factors in the re-

Why POSITIVE-DISPLACEMENT Superchargers for Ground Vehicles

Because ground-vehicle engines operate over a wide range of speeds, they demand varying volumes of air — at approximately constant boost.

Positive-displacement superchargers can satisfy this demand.

Centrifugal and axial-flow superchargers cannot. For them, both volume delivered and pressure are tied up with speed, for best efficiency.

Of the four types of positive-displacement superchargers available—Roots, vane, helical-screw, and internal gear—the Roots type is hard to beat for boosts under 7 psi. Volumetric efficiency is good and mechanical losses low for low pressures. But it compresses by blowback, and compression efficiency falls off badly as pressure ratio goes up, a fault that further development is unlikely to correct in this already well developed type.

For ratios above 1.5, the adiabatic compression that vane, helical-screw, and internal-gear superchargers can provide is essential.

These types have better overall and volumetric efficiencies. Since delivery air is cooler, a greater weight of air must be supplied for a given engine volume demand. A larger supercharger is needed, but engine power output is greater. A moderate difference in volumetric and overall efficiencies of adiabatic-compression superchargers over Roots superchargers produces a noticeable difference in engine horsepower at high speeds. The engine considered in the accompanying article gives 165 bhp with a Roots supercharger whose volumetric efficiency is 80% and overall efficiency is 56% at 10 psi, and 177 bhp with a helical-screw supercharger whose volumetric efficiency is 82% and overall efficiency is 69%.

Development of these newer adiabatic positive-displacement superchargers should bring still higher efficiencies.

More information on choice and design of superchargers has been given in Mr. Pigott's articles in the November 1945 and January 1947 issues of SAE Journal.
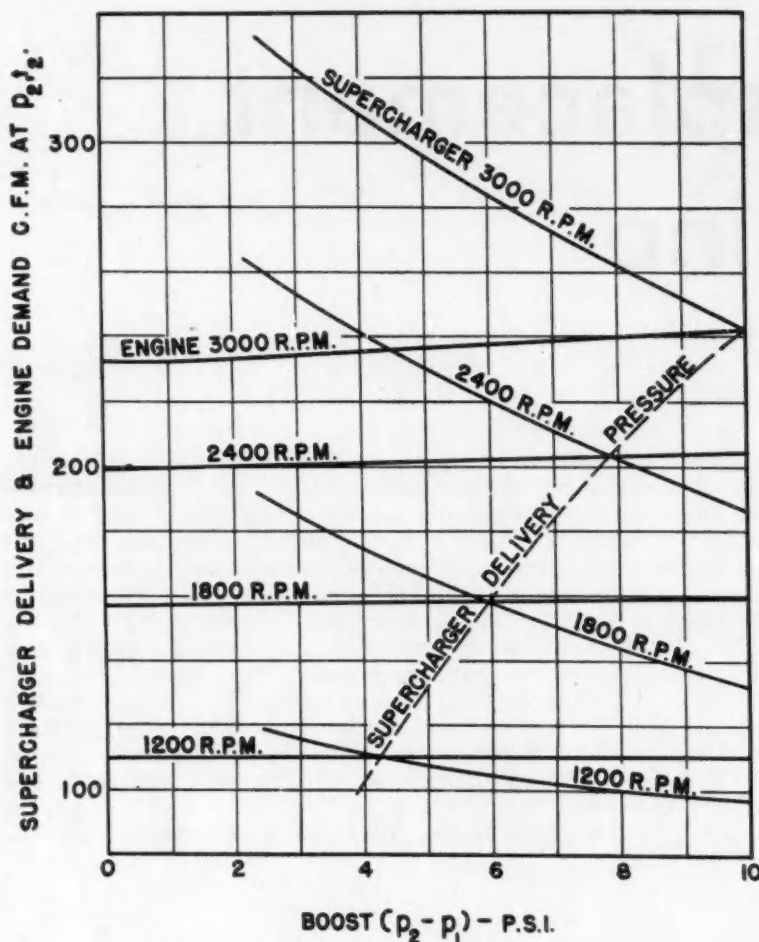
Fig. 3—Supercharger delivery and engine demand at supercharger delivery conditions as a function of boost pressure for various supercharger and engine rpm's

ciency below 100% is due chiefly to the intake breathing losses in the carburetor, manifold, and intake valves and to hot gases in the clearance volume. With increase in engine rpm, velocity of the gas in the manifold increases, intake breathing losses increase, and volumetric efficiency drops.

To maximize power at any speed, supercharging seeks to maximize mean effective pressure. Boost pressure must increase as engine volumetric efficiency decreases to maintain pressure inside the cylinder constant at maximum value despite engine rpm increase.

duction of volumetric efficiency below 100%: leakage and intake losses. Leakage varies with pressure difference. Intake losses are proportional to density and to the square of manifold speed.

For the positive-displacement supercharger, leakage, or slip, is the larger loss. All of the positive-displacement superchargers are "capillary" sealed. That is, they depend on close mechanical clearances, rather than rings or packing, to prevent leakage. Since the total clearance remains about the same no matter what the speed is, slip per unit of time does not vary much with speed. The greater the number of revolutions per unit of time, the less the leakage per revolution and the better the volumetric efficiency.

Slip is proportional to density and is a varying function of pressure difference. In the region of 2 to 7 psi boost, slip is roughly proportional to the square root of the pressure difference; at higher boosts, it approaches the first power of pressure difference. Generally, slip is in the neighborhood of 15 to 20% at full speed and 5 psi boost pressure.

The supercharger inlet losses vary with $\overline{rpm}^2$, but they are relatively small. As a result, volumetric efficiency is dependent chiefly on slip, and it improves with rpm.

The relative importance of the two losses is reversed in the engine. Leakage past pistons is very low, not over 0.5% at full speed when rings are in good condition. The reduction of volumetric effi-

To illustrate the analytical method of fitting a positive-displacement supercharger to an engine, a Roots-type and a helical-screw type supercharger have been chosen. The same method can be applied to other types of positive-displacement superchargers. For this example, maximum boost has been selected as 10 psi.

The supercharger manufacturer will usually be able to furnish volumetric efficiency and delivery temperature variation with speed and pressure difference, or equivalent data. From the manufacturer's data, charts like Fig. 1 can be plotted with boost pressure as the parameter. Fig. 1 gives air delivery by volume at delivery conditions for a Roots-type supercharger. Fig. 2 is a plot of the delivery temperature data for the same supercharger. (Supercharger inlet conditions of 14.7 psi and 100 F have been assumed.)

Engine air demand can be calculated for the engine intake conditions of pressure and temperature. Assuming a 346-cu. in.-displacement engine rated at 3000 rpm, displacement in cubic feet per minute will be the product of (346 cu in.) X (1/1728 cu ft per cu in.) X (3000 rpm) X (1 charge per 2 revolutions), or 300.4 cfm. Pressure drop through the manifold and inlet valve is 3.4 psi at 100 F and 14.7 psi. This yields a volumetric efficiency at 14.7 psi of 76.9%. Engine air demand is the product of displacement and volumetric efficiency. At the

Fig. 4—Indicated and brake horsepower
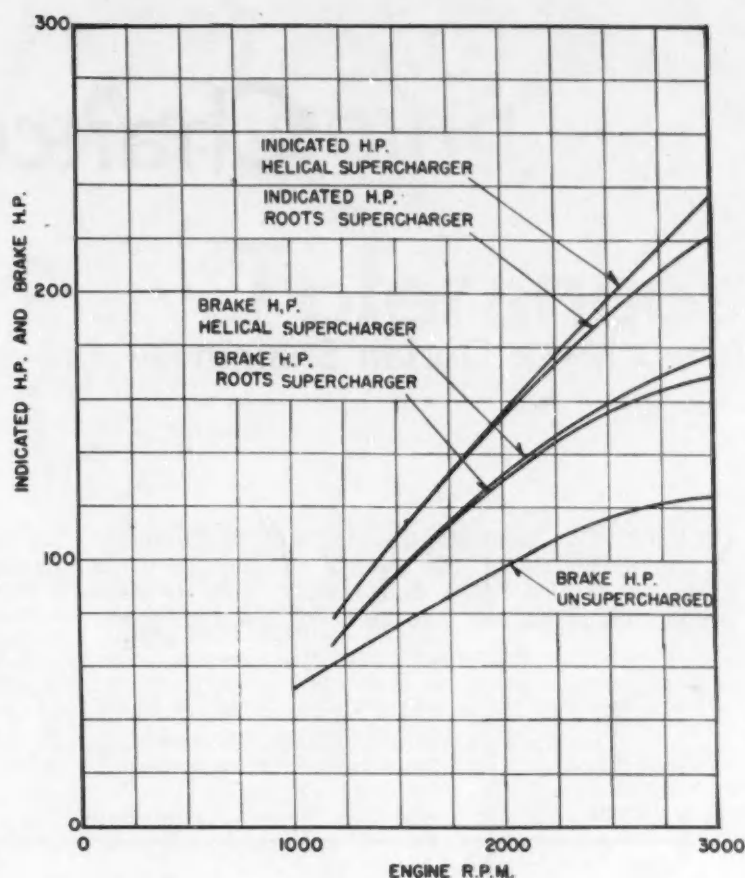
selected maximum boost of 10 psi, engine air demand figures out to be 242 cfm.

If the supercharger can supply full-speed engine air demand at the selected maximum boost, it is adequate for the engine. Fig. 1 shows that in this case supercharger delivery does match engine demand at 10 psi boost and 3000 rpm; delivery is 242 cfm. The required supercharger displacement is 400 cfm at 3000 rpm.

If supercharger delivery and engine demand had not matched exactly at 3000 rpm, but came close, the supercharger could be geared up or down a little from engine speed as required to match volumes. (The slight change in delivery temperature will have insignificant effect on engine demand.) Or maybe a compromise on maximum boost pressure could be accepted.

If supercharger delivery volume at selected maximum boost and rpm is way off engine demand, the supercharger is not suitable for the engine.

Since the analysis shows the supercharger in the example to be adequate at the design point, engine air demand has been calculated and plotted in Fig. 3 for selected speeds as a function of boost. This is the first step in estimating performance at off-design speeds, full throttle.

The pressure drop through the manifold is proportional to density and to the square of manifold velocity. Pressure drop increases as boost pressure increases, but pressure drop increases more slowly, so that the net effect of increase in boost is an increase in volumetric efficiency of the engine. That is why the engine demand curves rise with boost.

From the information at hand, it is possible to find the supercharger pressure at various speeds at full throttle. On Fig. 3, the plot of engine air demand versus boost for constant engine speeds, supercharger delivery versus boost can be cross-plotted from Fig. 2 for constant speeds. The point at which the set of curves crosses for a given speed defines the equilibrium volume for that speed. Connecting the points gives supercharger delivery pressures for all speeds.

Knowing these pressures, it is possible to predict horsepower of the supercharged engine. Those who have run engine tests supercharged and unsupercharged know that indicated specific fuel consumption changes unappreciably with absolute inlet pressure and temperature and improves only 3 or 4% with speed. The engine used for the example has an indicated specific fuel consumption of 0.50 lb per ihp-hr at 1000 rpm, which decreases to 0.47 at 3000 rpm.

To compute expected indicated horsepower, one can figure pounds of fuel per hour from the known air input and the fuel-air ratio, and divide the fuel flow by the indicated specific fuel consumption of the unsupercharged engine.

For the engine in the example, motoring horsepower decreases with increased boost from 45 hp at 3000 rpm and atmospheric intake to 33 hp at 10 psi boost, probably due chiefly to the lower viscosity of the oil at the higher operating temperatures. Subtracting motoring horsepower plus supercharger input horsepower, from indicated horsepower, gives brake horsepower. This engine, which gave 124 bhp unsupercharged, gives 169 bhp with the Roots supercharger.

Carrying out the same calculations for the helical-screw type, having a better overall efficiency, shows the resulting combination to be noticeably better. An improvement of some 13% in the overall efficiency of the supercharger produces substantially the same per cent improvement in the increased bhp over the unsupercharged engine, as shown in Fig. 4.

Chance Laws Aid

BASED ON PAPER* BY **Dorian Shainin** Hamilton Standard Propellers Division, United Aircraft Corp.

STATISTICAL methods, already being used in many shops to control the quality of manufactured products, reduce scrap and rework, and increase production rates, can also be used to assign toler-

ances to the dimensions of a product while it is still in the design stage.

Shewhart Control Chart

A most useful branch of statistical quality control is the Shewhart chart, which is a graphical record of quality plotted by the shop for each piece of equipment. The measurements from only 30 successive pieces from a machine need be plotted on one
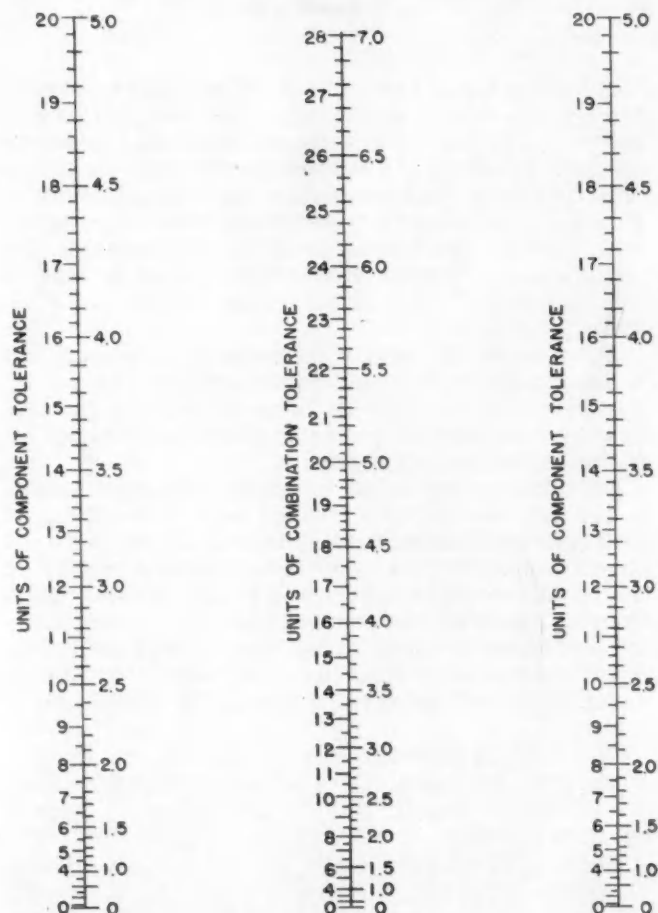
Fig. 1—Nomogram for combining tolerances statistically

For component tolerances of not more than 5 units, use righthand scales; when either component tolerance exceeds 5 units, use lefthand scales; when 20 units are exceeded, use righthand scales, calling 20, 2.0, and so forth.

Example: According to SAE Handbook, pitch diameter fit between ½-20, class 3 nut and bolt is allowed to vary from size on size to 0.0052 loose, 0.0026 being allowed as tolerance for each component. Nomogram shows 3.69 units combination tolerance for component tolerances of 2.6 units each. Thus, if machinery is just capable of meeting 0.0026 tolerance and control charts are maintaining average size at midpoint of tolerance ranges, 0.0052-0.00369, or 0.00151 of allowed assembly tolerance would not be used, for all practical purposes.

Next, since 0.0052 is allowed for assembly, use this value on center scale to give 0.0037 on each side scale as allowed natural tolerance for each component. Since allowable tolerance for each component of ½-20, class 2 fit is 0.0036, with a control chart one can get class 3 assemblies at class 2 prices.

Designer in Assigning

Tolerances

of these charts to give a reasonable estimate of its natural tolerance.

The natural tolerance of a machine is the effective total range in tolerance of the parts produced on it when all erratic or assignable causes of variation have been eliminated. It exists because, even when all possible causes of variation have been traced and eliminated, there still remains a residual variation that cannot be economically removed. This residual spread is considered to be due to the chance combination of the innumerable constant causes of variation that are still at work. (Of course, such causes that either cannot be found or be economically removed today may someday be so treated, through technical progress.)

Thus, when the experienced operator knows the natural tolerance of his machine, he is able to use its Shewhart chart to detect the presence of any variation not inherent in the process before it does any damage—whether it is caused by man, machine, or material.

Application to Design Tolerances

When a shop uses Shewhart charts to keep vigil over its operations, the designer can use the nomogram shown in Fig. 1 to determine the combination tolerance that would result when two parts, each held to a known tolerance, are assembled.

It will be noted that the combination tolerance is considerably less than the algebraic sum of the individual tolerances, so that the designer is able to assign workable tolerances to components, even when the algebraic sum of their tolerances would far exceed the limits for a workable assembly.

This chart is based on the principle that when two parts, each selected from a pile of parts produced with the aid of a control chart, are assembled, the particular two parts selected for each assembly will be purely a matter of chance. Thus, the likelihood that any two parts being selected for a particular assembly would both be at the extreme limits of their respective tolerances is very small. Actually the nomogram in Fig. 1 has been constructed so that the chances that the two parts cannot be assembled because their combined tolerance is over the workable limit are only 1.3 in 1000.

At this point it might be asked, "What about the

1.3 times when the parts won't form a workable assembly?" The answer is that, although conventional methods of determining tolerances theoretically take care of 100% of the parts, an actual check of inspection methods in shops not using statistical control generally shows that such methods are far from infallible. In fact, in many cases they have been found to be as much as 50 times worse than when statistical control is used.

Fig. 1 can also be used to determine the combination tolerance of an assembly of more than two components by pairing the first combination tolerance with the tolerance of the next part, and so on, each resultant sum being read on the center scale.

Fig. 2 has been developed for the special case where more than two components are involved and the individual tolerances are equal—or close enough
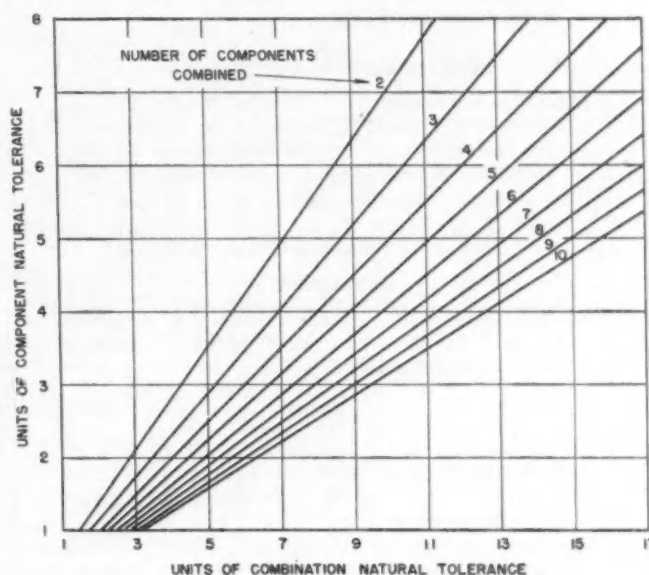

Fig. 2—Chart for statistically combining two or more equal component tolerances.

to make that assumption justified for purposes of a first approximation. Then, starting with the known component tolerance, the assembly tolerance can be determined with one reading instead of reentering the nomogram. Also, starting with a known assembly tolerance, the component tolerance can be found immediately, while the nomogram would require a trial-and-error procedure.

If designers take full advantage of these charts, they will no longer have to distribute the tolerance load among parts according to empirical rules concerned with the size of the dimension, internal or external dimensions, whether the construction of the work requires a type of milling, single-point boring, grinding, or the like. In a statistically controlled shop factual data are available that will permit engineering, production engineering or tooling, and the shop to work as a unit on these matters.

The shop, from its existing control charts, furnishes a table of natural tolerance against the part number and dimension being fabricated, classified by equipment identification tag number.

Further, to aid him in distributing the tolerance load for a new design, the designer has such a tabulation and a schedule from production engineering showing the expected idle time on particular machines. The nomogram of Fig. 1 should then make possible many an otherwise "impossible" job. If, even with the very substantial extra tolerance thus made available by this method of statistical addition, the required end tolerance cannot be achieved, the new equipment needed is known immediately. What it must be able to hold to is also known. In some cases arrangements might be made for a test run to develop a Shewhart chart and thus prove the adequacy of the equipment even before it is purchased.

Drawing Notation

Since each tolerance determined by the statistical method is valid only when a control chart keeps the distribution free from other than just momentary assignable causes of variation, it seems desirable, especially at a plant just becoming familiar with statistical methods, to have a special marking on drawings to indicate that all possible allowances have been made and that one should not deviate on parts beyond these limits relying upon the same probability concepts over again.

It is suggested that an SAE committee might develop some drawing notation as a recommended standard practice. For instance, the special dimensioning might be: "0.4662 (0.0018)," which would mean, "0.4662 plus and minus 0.0018 maximum variation of individual sizes as controlled by a Shewhart chart." The first figure gives the desired average value, and that in the parentheses the maximum allowable "three standard deviation" variation from that average, it being understood that the parentheses denote use of the statistical method.

This type of dimensioning will be an indication that the tolerance has been computed statistically and is therefore properly economical. Second, it will be clear to production that they have a tolerance commensurate with capabilities and that they should not feel the constant need of asking for any more tolerance. Third, production's choice of equipment to be used can be properly guided either by using the machine that the designer had in mind, a similar one, or one with an even closer natural tolerance than is indicated by the control chart records on file. Fourth, such control of rough and finished dimensions means that forgings and castings certainly need carry less extra raw material to guarantee finishing, with obvious resultant economies. Finally, the most important advantage is that the dimension will average close to the standard average and the parts should all be within specification, since the machine is capable of holding to these values when the Shewhart type of control chart is used. Such charts keep the operator continuously aware from piece to piece as to whether the variations operating are inherent or foreign. All these economies—and the good production practices resulting therefrom—should assure that one keeps the best possible position in a competitive field.

CRC Releases Five Reports

THE following Coordinating Research Council reports have been released for distribution and are available from SAE Special Publications Department, 29 West 39th Street, New York 18, N. Y. (This is a complete list of CRC reports released since publication of the listing of CRC reports on pp. 81-85 of the November, 1948, SAE Journal.)

MOTOR FUELS

Gasoline Additives

CRC-226—Report on 1945 Desert Storage Tests on Stability of 80-Octane-Number, All-Purpose Gasoline (9/18/46) Price: $2.00 to SAE Members; $4.00 to Nonmembers.

Engine Varnish and Sludge

CRC-227—Evaluation of Effects of Engine Design, Operating Variables, Fuel and Lubricating Oil Characteristics on Engine Sludge and Varnish (5/12/48) Price: $1.50 to SAE Members; $3.00 to Nonmembers.

AVIATION FUELS

Detonation

CRC-228—Knocking Characteristics of Aviation Fuels (3/10/48) Price: $2.00 to SAE Members, $4.00 to Nonmembers.

Volatility

CRC-229—Analysis of Results of AAF-CRC Fuel Volatility Test Program, Winter 1945-46 (5/24/48) Price: $2.00 to SAE Members; $4.00 to Nonmembers.

CRC-230—Analysis of Results of AAF-CRC Fuel Volatility Test Program, Winter 1946-47 (4/5/48) Price: $2.00 to SAE Members; $4.00 to Nonmembers.

Charts Indicate
Most Profitable Cruise Plan

BASED ON PAPER* BY

S. T. B. Cripps

Assistant to Civil Air Attache
British Embassy, Washington, D. C.

DIRECT flying cost and revenue can be linked so that an airline flying crew can easily assess the profit or loss incurred by various flight procedures when they are making up the flight plan.

Modern long-distance transports offer a number of possible methods of operation—maximum power, maximum speed, or maximum-range speed, for example. Charts can be developed to show the crew which flight procedure will be most profitable under the conditions of payload and wind velocity prevailing for a particular flight.

By evaluating flight procedures in terms of dollars, the charts furnish a sound basis for cruise control. (As it is now, engineering departments are inclined to press for operation at best economy from the powerplant and maintenance point of view, flying crews like to get the flight carried out as quickly as possible, and other elements want to minimize fuel used.)

A set of charts applies only to the aircraft for which it was calculated. For purposes of illustrating the method, charts have been developed for the

Lockheed Constellation 749. Table 1 shows the assumed cost data. Three flight procedures will be evaluated: cruise at 190 knots, at 1.145 times the speed for velocity for maximum range, and at 1.1 times the speed for maximum range. Operation at 20,000- and 10,000-ft altitudes will be considered.

The method is to work cost and payload data into a form which will show costs and available revenue versus wind components for each cruising procedure for a particular route distance and flight altitude.

First step is to work up cost data for each cruise procedure under consideration from the manufacturer's basic data and the assumed direct flying costs. This has been done in Tables 2 and 3 for cruising at 1.1 times the speed for maximum range. Simliar tables should be made up for the other cruise procedures.

Fig. 1 has been plotted from cost data on Table 3 and tables for the other two cruising procedures. Cruise at 1390 hp has been plotted as well. The chart applies only to operation at 20,000 ft.

Although the maximum fuel limitation is the same for all cruising procedures, cruising 12.5 hr on the 1390-hp procedure costs $4150 while cruising 18.5 hr on the 1.1-times-maximum-range-velocity procedure costs $5400, according to Fig. 1. Reason for the spread in maximum-endurance cost figures is that

Table 1—Assumed Costs

Cost item No.

1	Fuel cost	.25	per gal per hr
2	Oil cost	.010	per lb per bhp per hr × 0.85
3	Aircraft depreciation	$ 31.10	per hr
4	Engine depreciation	13.25	
5	Engine overhaul repair	19.24	
6	Aircraft overhaul repair cost	21.70	
7	Aircraft and engine ground service	16.90	
8	Crew cost and expenses	89.55	
9	Aircraft insurance	18.08	
	Fixed cost/hr., items 3-9	$209.82	per hr

Table 2—Performance Calculations for 1.1-Times-Maximum-Range Velocity at 20,000 ft

Zone Fuel Used, lb	Total Fuel Used, lb	Time Zone, hr	Average Zone Time, hr	Total Time, hr	Fuel Consumption, lb per hr	Average Zone Bhp	Average Sfc	Average TAS, knots	Total Average TAS, knots	Gross Weight, lb	Average Gross Weight, lb	Distance, nautical miles	Total Distance, nautical miles
										102,000			
2,240	2,240	0.670		0.670	3,345	1,400	0.5970	168.5	168.5	99,760		113	113
4,760	7,000	2.100	1.720	2.770	2,265	1,212	0.4660	241.0	223.5	95,000	97,380	506	619
5,000	12,000	2.380	3.960	5.150	2,100	1,142	0.4600	238.0	230.0	90,000	92,500	566	1,185
5,000	17,000	2.555	6.427	7.705	1,958	1,074	0.4550	234.0	231.5	85,000	87,500	599	1,784
5,000	22,000	2.790	9.100	10.495	1,795	993	0.4515	229.5	231.0	80,000	82,500	640	2,424
5,000	27,000	3.050	12.015	13.545	1,638	909	0.4510	224.0	229.5	75,000	77,500	684	3,108
5,000	32,000	3.320	15.205	16.865	1,508	831	0.4540	218.0	227.0	70,000	72,500	724	3,832
2,350	34,350	1.665	17.695	18.530	1,412	771	0.4580	213.0	226.0	67,650	68,825	354	4,186

depreciation has been figured on an hourly basis. If it were figured on a trip basis instead, the spread would be narrowed.

The next step is to calculate and plot revenue for the range of payloads. This information is plotted on Fig. 2 for the 3000-nautical-mile New York-London route, along with various load factors. The plot highlights the fact that a 58% load factor produces a revenue of $9150, 75% of the maximum available revenue. This is because Type 31 interior arrange-
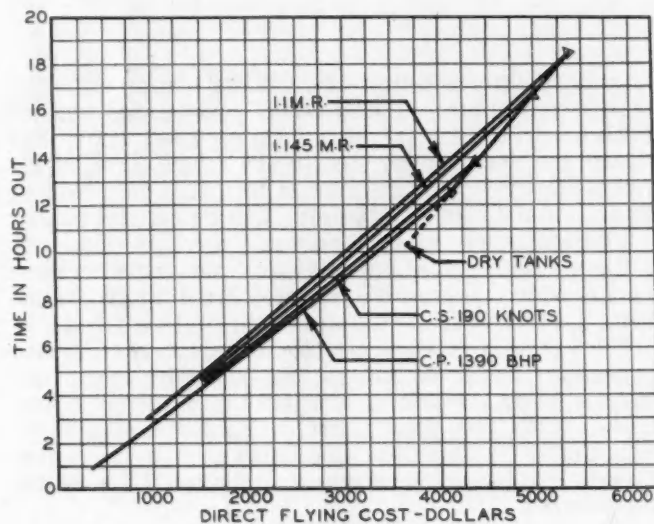

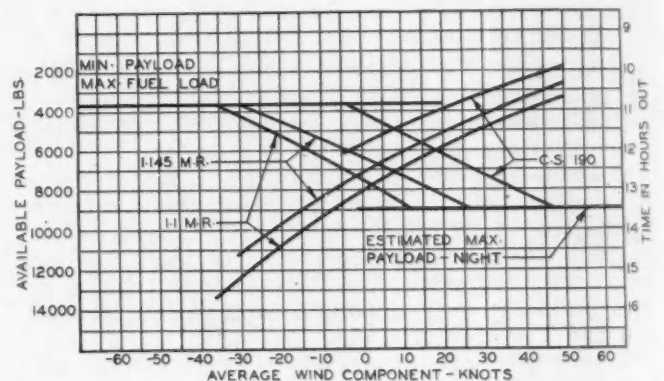Fig. 1—Cumulative direct flying cost versus time in hours out at 20,000 ft

Fig. 3—Allowable payload and time in hours out versus wind component for route distance of 3286 nautical miles flown at 20,000 ft
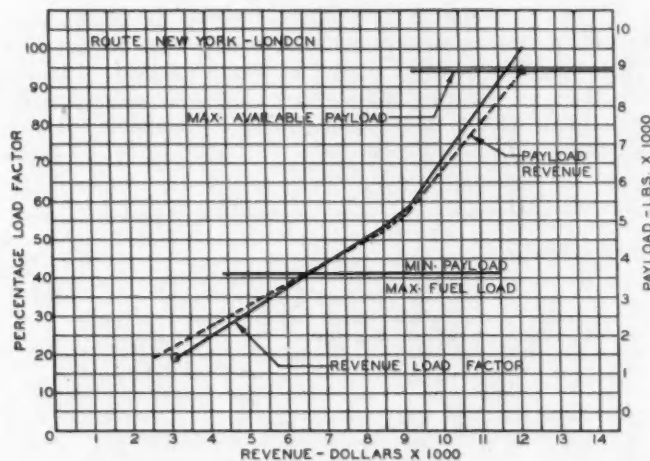

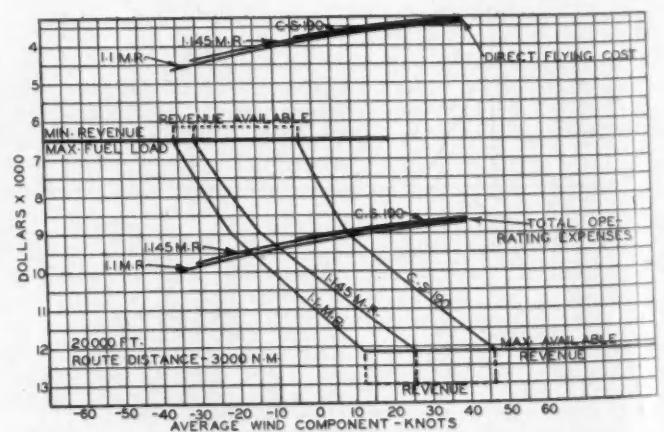Fig. 2—Load factor and payload versus revenue for New York-London route

Fig. 4—Cost and revenue versus average wind component for route distance of 3000 nautical miles at 20,000 ft

Table 3—Costs Calculated on Basis of Table 2 for Same Cruising Procedure

Time Interval, hr	0.67	2.100	2.380	2.555	2.790	3.050	3.320	1.665
Total Time, hr	0.67	2.770	5.150	7.705	10.495	13.545	16.865	18.530
Fuel Cost, $ (Item 1)	93.30	198.000	208.000	208.000	208.000	208.000	208.000	98.000
Oil Cost, $ (Item 2)	4.69	12.700	13.600	13.750	13.850	12.750	12.650	6.650
Items 3-9, $	140.50	440.000	500.000	536.000	585.000	640.000	696.000	349.000
Cost for Time Interval, $	238.49	650.700	721.600	757.750	806.850	860.750	916.650	453.650
Total Cost, $	238.49	889.190	1610.790	2368.540	3175.390	4036.140	4952.790	5406.440

ment has been assumed, bringing in the higher fare of sleeper passengers.

Figs. 1 and 2 can be combined with a third type of plot, similar to Fig. 3, to give revenue available and total operating expense versus average wind component. (Charts like Fig. 3 are derived from consideration of the airplane's operating characteristics. Actually Fig. 3 was derived for a route distance of 2860 nautical miles flown at 20,000 ft.)
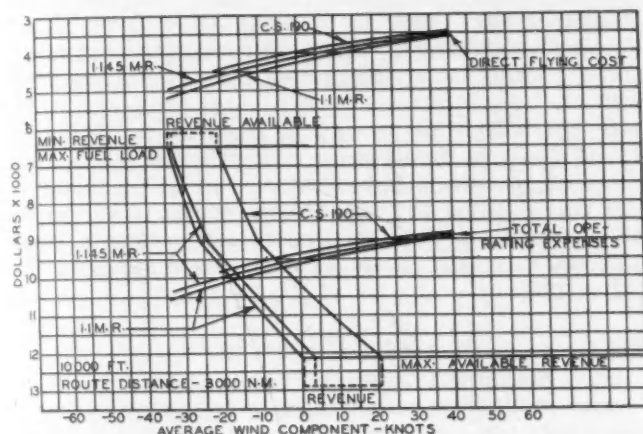

Fig. 5—Cost and revenue versus average wind component for route distance of 3000 nautical miles at 10,000 ft
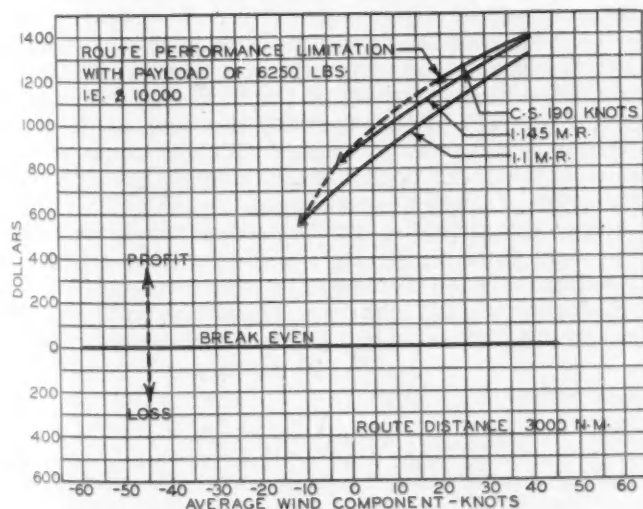

Fig. 6—Profit available with 70% load factor versus average wind component at 20,000 ft

The result is a chart like Fig. 4, which has been plotted for a 3000-mile route at 20,000 ft.

Cost figures for Fig. 4 are obtained from the payload-wind chart and Fig. 1. To plot cost values for one operating procedure, it is necessary to select average wind component values and pick off corresponding time values from the former chart, then with those time values, to go into Fig. 1 and pick off corresponding cost values.

Revenue figures for Fig. 4 are obtained from the payload-wind chart and Fig. 2. To plot revenue values for one operating procedure, the payload-wind chart is entered at various values of wind component and corresponding values of payload are picked off. Then the revenue corresponding to each payload value is determined from Fig. 2 and plotted on Fig. 4 for the wind components.

Also plotted on Fig. 4 are lines of total operating expense. These were obtained by assessing indirect costs as 1.3 times direct flying costs under zero head-wind for each cruising procedure.

Fig. 4 applies only to operation at 20,000 ft for the 3000-nautical-mile route. Fig. 5 is a similar plot for operation at 10,000 ft.

Besides indicating total operating expenses and revenue obtainable for any condition of average wind component for any of the cruising procedures, Figs. 4 and 5 show the extreme adverse wind condition at which the operator can break even with minimum payload and, with a given payload, the wind condition required to break even.

More specifically, for conditions of say a 33-knot wind at 20,000 ft and a 20-knot wind at 10,000 ft, the charts show that with the maximum-payload revenue, the 1.145-times-maximum-range-velocity procedure at 20,000 ft brings the biggest profit, about $3450. The 1.1 cruise procedure at 20,000 ft would bring about $3400 profit, and any of the procedures at 10,000 ft would bring less. Cruising at a constant speed of 190 knots, even at 20,000 ft, would decrease allowable payload to the point where it could bring only $11,200 revenue, thereby reducing profit to $11,200 minus $8700, or about $2500.

To show even more clearly which flight procedure is best when less than the maximum allowable payload is to be carried, profit versus wind component can be plotted for various load factors. Fig. 6 shows such a plot for a load factor of 70%. The dashed line indicates points where the maximum allowable load for various cruise procedures is just equal to the 70% load-factor weight, which is 6250 lb. In the area left of the dashed curve, maximum allowable payload is less than 6250 lb.

Fig. 6 indicates the wisdom of using the fastest cruising procedure possible, in this case.

IMPROVED WING

BASED ON PAPERS* BY

Frank B. Sandgren,

Bell Aircraft Corp.

and K. E. Van Every,

Douglas Aircraft Co., Inc.

SINCE the science of aerodynamics shows that speed of high-performance aircraft for transonic flight can be raised most readily through boosting critical Mach number by use of thinner airfoils and swept wings, ways are being found to make these new kinds of wing structure strong, light, and safe.

As airplane speed exceeds the critical Mach number for the airplane, drag shows an abrupt increase. The further critical Mach number and accompanying drag rise can be deferred, the faster an airplane with given available-thrust characteristics can fly.

Reducing wing thickness and sweeping back wings are two basic ways to increase critical Mach number. Both have the effect of decreasing effective air velocities over the wing. Fig. 1 compares effectiveness of the two methods, as well as effectiveness of reduced aspect ratio. Combination of airplane components to minimize interference losses and removal of boundary layer can also raise critical Mach number, but these two methods are not so well understood.

Thin, high-speed wings pose new problems in structural design. Besides torsional loads, wing skins must bear buckling stresses—yet not buckle.

Wide panels are desirable from the standpoint of ease of fabrication. And the wider the panel, the thicker the skin must be to maintain a given allowable buckling stress. The big problem is to get skin thick enough to withstand the loads but light in weight.

Swept wings are tricky to analyze for stresses. Their analysis involves no new principles in structures or elasticity, but allowance must be made in the calculations for the effects of the changes in wing direction, a slow process with conventional analysis methods. Rapid approximate methods are being sought.

M_{CR} Sets Maximum Speed

How maximum speed of high-speed, high-performance aircraft is increased by increasing critical Mach number can be seen from Fig. 2. For aircraft powered with engines of sufficient thrust to permit flight at transonic Mach numbers, speed is primarily limited by the steep drag rise which occurs after the critical Mach number has been exceeded. Drag rises so sharply after critical Mach number that it is impossible to increase airplane speed further without tremendous increases in power.

Fig. 2 shows power required and power available in thrust coefficient form. Thrust coefficient available is the thrust output of the powerplant divided by the product of the dynamic pressure of the air and the wing area. Thrust coefficient required is approximately the parasite drag coefficient. The intersection of these curves determines the maximum speed of the airplane. If the critical Mach number is increased, as shown by the dotted line, a corresponding increase in maximum speed results.

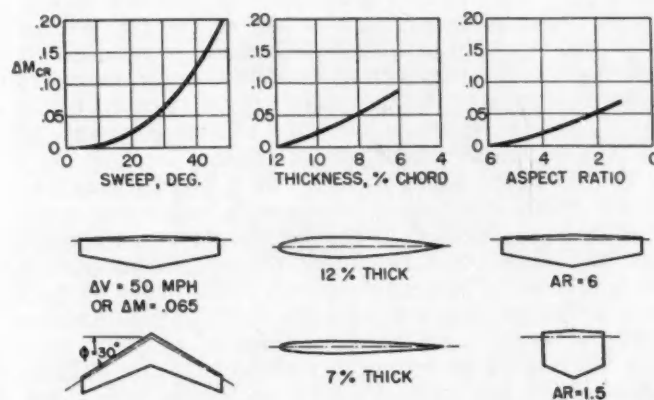Reducing wing thickness shortens the path of the air around the airfoil, allowing it to travel from

Fig. 1—Comparison of methods for increasing wing critical Mach number

DESIGNS Raise Top Speed

of Transonic Airplanes

leading to trailing edge at a lower local Mach number for a given airplane Mach number. This puts off drag upswing to higher airplane Mach numbers and increases maximum attainable airplane speed.

Rate of increase of critical Mach number with rate of decrease in thickness is unfortunately low. Critical Mach number increases 0.012 for an airfoil thickness-chord ratio decrease of 0.01. Large increases in the critical Mach number, therefore, require large changes in wing thickness.

To keep thin wings light, structures designers are advancing the trend toward thicker wing skins.

When all-metal wings were first used, the primary function of the outer skin was to carry the torsional loads. As the speed of airplanes increased, greater torsional loads were applied—by the introduction of flaps, for example. Skin thickness was increased to around 0.40 or 0.50 in., but generally chordwise stiffeners were used, and the skin was allowed to buckle at low airplane accelerations. The bending strength of the wing, principally in compression, was still concentrated in heavy, high-allowable-stress capstrips.

When wings were reduced to 15% thickness at the root and torsional requirements called for skins of 0.064 in. or greater, spanwise stiffeners were employed to obtain some benefit from the skin in bending by increasing its buckling allowable greatly, although ultimate allowable stress of the skin-stringer combination was less than that of the adjoining capstrips.

In 1944, when speeds reached the neighborhood of 550 mph, it was no longer possible aerodynamically to permit the skin to buckle at less than limit-load airplane accelerations. This required much closer stiffener spacing or additional spanwise stiffeners, so that the bending material was transferred still more to the skin and stringers.

With wings of 6 to 9% thickness, skin became even thicker, and the depth of the stringers necessary to support this skin increased likewise. Finally stiffeners on the upper and lower airfoil surfaces, which were drawing closer together, would almost touch each other. The logical step was to join these stiffeners into a single channel web so that the skins

stabilized each other. Wing construction became multicellular, with all the material used in carrying bending and torsional loads and a slight excess of material for carrying shear loads.

Sandwich Construction Used

This new type of construction calls for structural data on the buckling and ultimate allowables of heavy plates in compression and the required stiffnesses of the channel beams to support this heavy skin, data now being acquired.

Since these modern thin wings with multiple webs are extremely difficult to fabricate, especially to buck rivets, panels should be wide. To maintain the same buckling stress, effective thickness of the skin must be increased directly with panel width.

This can be accomplished by making the skin a built-up section, such as a sandwich of dense faces and light core. Good skin sandwiches are light in weight yet afford the advantages of thick solid skins: smoothness and accuracy of wing contour to delay aerodynamic turbulence, and concentration of material at wing periphery where it is most effective for bending and torsional stiffnesses.
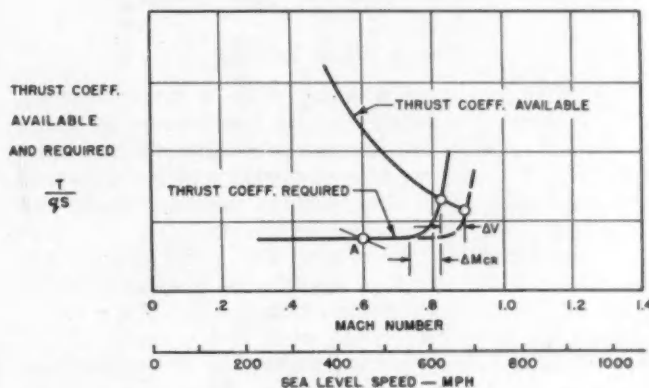

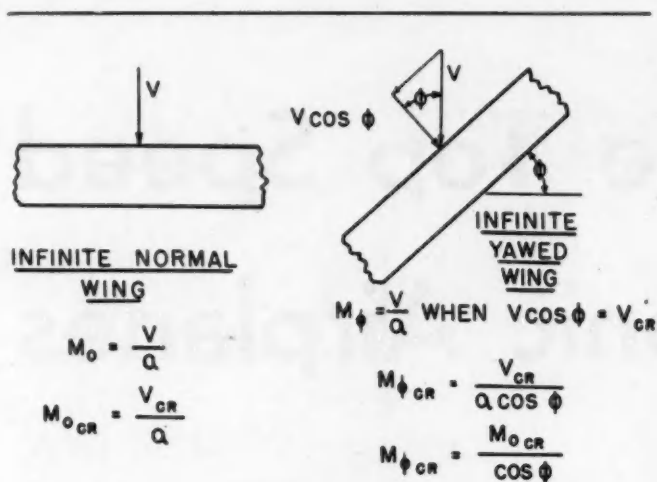Fig. 2—Influence of critical Mach number on maximum airplane speed

Fig. 3—Diagram illustrating basic concept of swept wing

The figure contains:

INFINITE NORMAL WING

$$M_O = \frac{V}{a}$$

$$M_{O_{CR}} = \frac{V_{CR}}{a}$$

INFINITE YAWED WING

$$M_\phi = \frac{V}{a} \quad \text{WHEN} \quad V\cos\phi = V_{CR}$$

$$M_{\phi_{CR}} = \frac{V_{CR}}{a\cos\phi}$$

$$M_{\phi_{CR}} = \frac{M_{O_{CR}}}{\cos\phi}$$

Peripheral loading due to bending and torsion is a useful parameter for selecting a wing construction for a high-speed airplane. Aluminum-alloy and perpendicular-balsa sandwiches have been used to carry loadings as high as 8000 psi. Neglecting wing thickness and fabrication procedures, medium-gage skin, reinforced with closely spaced spanwise stiffeners, is optimum for loadings from 8000 to 14,000 psi. Spanwise corrugations between flat skins have been used for loadings ranging from 15,000 to 30,000 psi. The thick solid-skin construction used on the X-1 receives a loading of 25,000 psi.

In the type of wing construction where all or part of the bending strength is in capstrips, the increase in bending moment toward the wing root may be efficiently and simply carried by an increase in capstrip areas. But in thick skin construction, where almost all of the bending moment is carried in the skin, such taper in material cannot be accomplished so simply. Machine-tapered skins have been employed in the X-1, but it is an expensive solution.

Now that thick skin is being used as the primary carrier of bending stresses, advances in reduction of wing weight hinge upon acquisition of more structural data on the buckling and ultimate allowable stresses of thick plates and the optimum structure to support these plates. A simple, economical means of tapering skin thickness is needed, too.

Swept Wings Studied

Comparing a yawed wing with a normal wing, both of infinite span, illustrates how sweeping wings backward or forward increases critical Mach number. Fig. 3 diagrams the two wings in an assumed inviscid fluid. For the infinite normal wing, the normal velocity, V, determines the pressure distribution and forces on the wing. For the yawed wing, the pressure distribution and forces are determined solely by the normal velocity component, $V\cos\phi$.

Mach number for either wing is the ratio of the velocity of the approaching stream to the velocity of sound, a. For the normal wing, there is a certain critical velocity which corresponds to the critical Mach number. For the yawed wing, critical Mach

number is reached when the normal component, $V\cos\phi$, equals the critical velocity. As Fig. 3 shows, critical Mach number for the yawed wing, being equal to the quotient of Mach number for the normal wing divided by the cosine of the angle of sweep, will always be greater than for the normal wing at the same V.

The same analysis can be applied as a first approximation to a finite sweptback wing. Because of root and tip losses on a finite swept wing, the full theoretical gain in critical Mach number is not realized. With usual aspect ratios, the gain is approximately half of the theoretical value—or for convenience, the actual critical Mach number is equal approximately to the quotient of the theoretical Mach number divided by the square root of the cosine of the angle of sweep. Thus for a sweep angle of 35 deg, critical Mach number increases 0.08.

Stress analysis of the outer portions of swept wings, where the bending structure is normal to the torsional axis of the wing, can be handled like analysis of straight wings. But the analysis and design of the root region of the wing requires the solution of several new problems by more advanced methods of stress analysis.

Where the swept outer portion of a wing is joined to a normal portion, torsion about the torsional axis and bending moments perpendicular to this axis must be rotated into a new set of reference axes perpendicular and parallel to the centerline of symmetry of the airplane. This rotation generally occurs at either the side of the fuselage or the centerline of the airplane.

Shortcuts Sought

On airplanes where the sweep of the wing is decreased toward the tip in a series of steps (in order to maintain the same critical Mach number along the entire span through a combination of swept angle and thickness ratio), each change of direction involves a rotation of axes.

Where wing direction changes, distributions of stresses in the triangular shear panel, beam shear webs, root ribs, and crossover wing bending material are extremely redundant, which means that deformations and continuity of the structure must be considered in the analysis.

Although the analysis can be carried out using only long known principles of structures and elasticity, the amount of analysis involved and the chances for error cause the typical analyst to lack faith in his results until he has checked his work against instrumented static tests.

A change in design often multiplies the labor because a considerable part of the analysis has to be repeated with different values. To speed design of swept wings, rapid approximate methods are being developed for determining weight effects of changes in thickness ratio, taper ratio, aspect ratio, wing attachment means, and arrangement of internal structure, where there is the additional variable of angle of sweep.

So far, the number of studies and designs made is insufficient to permit generalization on the most efficient type of structure for the various specific cases that arise.

ENGINE OPERATIONS
At Low Temperatures

William Weitzen

Extreme Weather Unit
Air Materiel Command, USAF

MODERN USAF cold weather tests have been conducted on an increasing scale since 1941 in Alaska. Current production type aircraft and engines are tested under actual low temperature conditions to increase the Air Forces' background of operating knowledge and to assist in its developmental programs.

The existing Air Force low temperature limit of – 65F was established in 1942.

This limit has been shown to be substantially sound although at present it is being questioned and Aeronautical Board Sub-Committee ANC-22 is now investigating this limit.

The world's sea level minimum isotherms are shown in Fig. 1. During the winter of 1946-47 the western hemisphere record low of – 83F was reported in the Yukon, while an eastern hemisphere low of – 94F was recorded in Siberia.

Fig. 1—Minimum surface isotherms on world-wide scale

APPROXIMATE
ABSOLUTE MINIMUM ISOTHERMS
DEGREES FAHRENHEIT

RECORD MINIMUM VALUES
♫ = – 94
★ = – 83
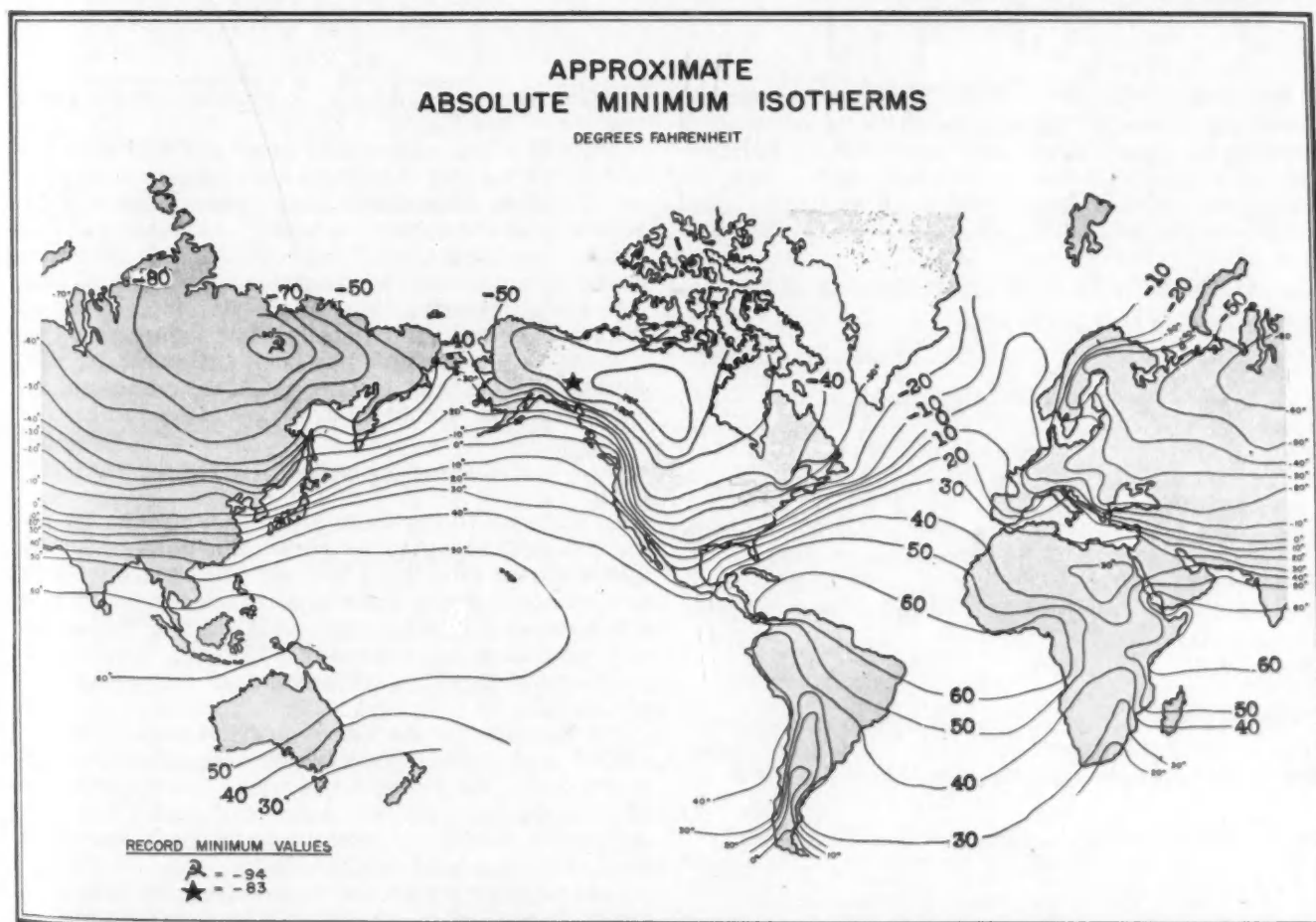
Fig. 2—Schematic layout of standard Air Force oil dilution system, including vacuum pump dilution installation
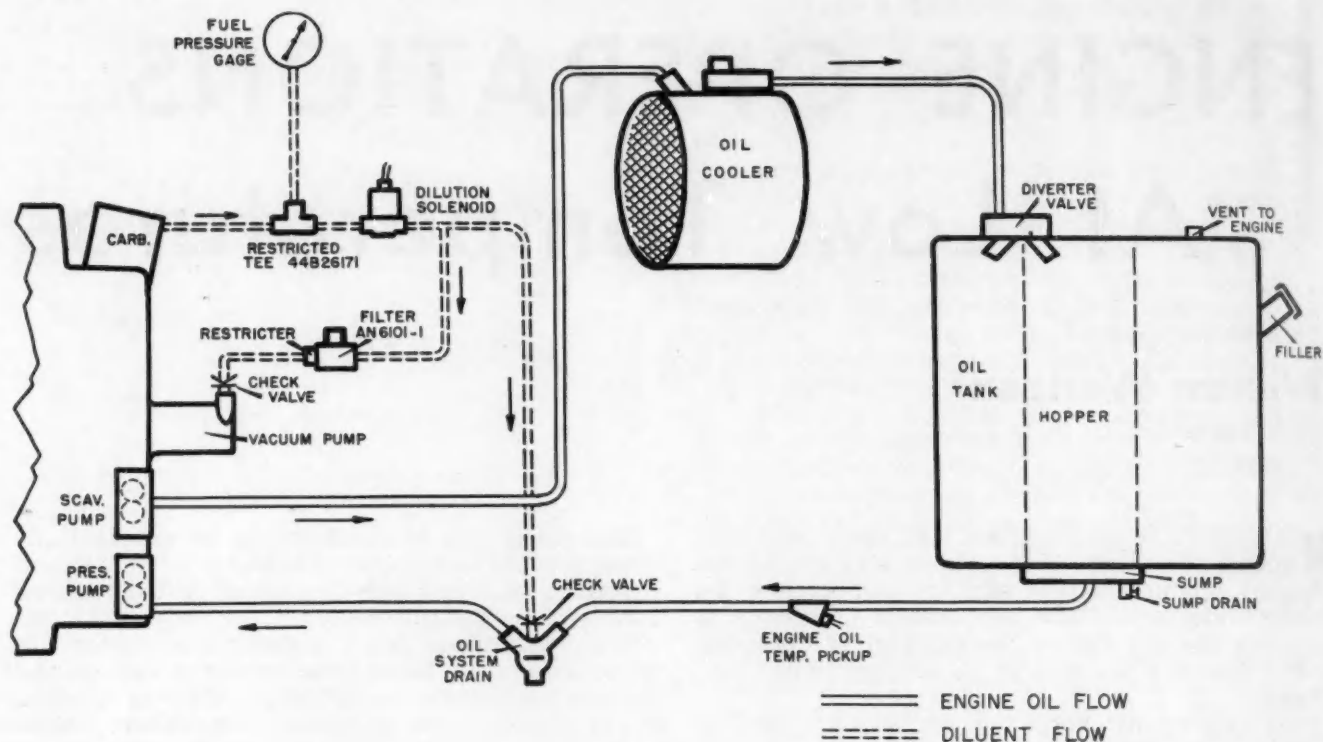
Oil systems continue to be a major problem in Arctic operations. Oil is inherently unsatisfactory because of its relatively high pour point. Reciprocating engine oils are particularly bad. Data on the pour point characteristics of presently used reciprocating and turbo jet engine oils follow:

POUR POINTS FOR USAF ENGINE OILS

RECIPROCATING ENGINES

SPEC	GRADE	Pour Point F Max. (Undiluted)	Pour Point F Max. (Diluted 35%)
AN-0-8	1120	+20	−65
	1100	+10	−65
(Supersedes)	1080	0	
(AN-VV-0-446)	1065	0	

TURBO-JET ENGINES

AN-0-9	1015	−50	
(Supersedes)			
(AAF 3606)	1010	−70	

Oil dilution is one means to obtain satisfactory engine crankability and oil pumpability under most low temperature conditions. The basic Air Force oil

dilution system has long been satisfactory for use in the states, see Fig. 2.

This dilution system has been proven to be unsatisfactory under extremely low temperature operations and investigations have been under way for several years to correct or modify oil systems so that satisfactory and consistent cold weather operation would be obtainable with service type aircraft. Fig. 3 shows progressive steps in the development of oil tank hopper and sump details. The segregating type system, D, lower right, has been satisfactorily used during preliminary testing in Alaska and indications are that this basic system will be successful.

Studying Other Systems

In addition to the basic oil system circuit, experimental work is underway with a hot tank oil system and a closed circuit oil system. Neither have ever been checked under low temperature conditions and due to their special design features, the Air Forces will undoubtedly encounter additional and severe problems that will adversely affect the mechanics of dilution.

Oil dilution can and does provide engine crankability under conditions which would present extreme difficulties were it not used. Most important of all it provides for oil "pumpability and flowability" under starting conditions at oil locations where heat, if used, would not penetrate.

Cold starting reciprocating engines have long been under investigation by the USAF and the engine

SCAVENGED OIL →

MAIN OIL TANK

HOPPER

FILLER

MAKE UP OIL PATH

TO ENGINE ←

SUMP
SUMP DRAIN

Ⓐ

SCAVENGED OIL →

HOPPER EXPANSION SPACE

MAIN OIL TANK

GRAVITY FLAPPER VALVES

HOPPER

MAKE UP OIL PATH

FILLER

TO ENGINE ←

SUMP
SUMP DRAIN

Ⓑ

MAIN OIL TANK

HOPPER

GRAVITY POPPET VALVE

MAKE UP OIL PATH

TO ENGINE ←

SUMP

Ⓒ

MAIN OIL TANK

HOPPER

WARMUP FINS

MAKE UP OIL PATH
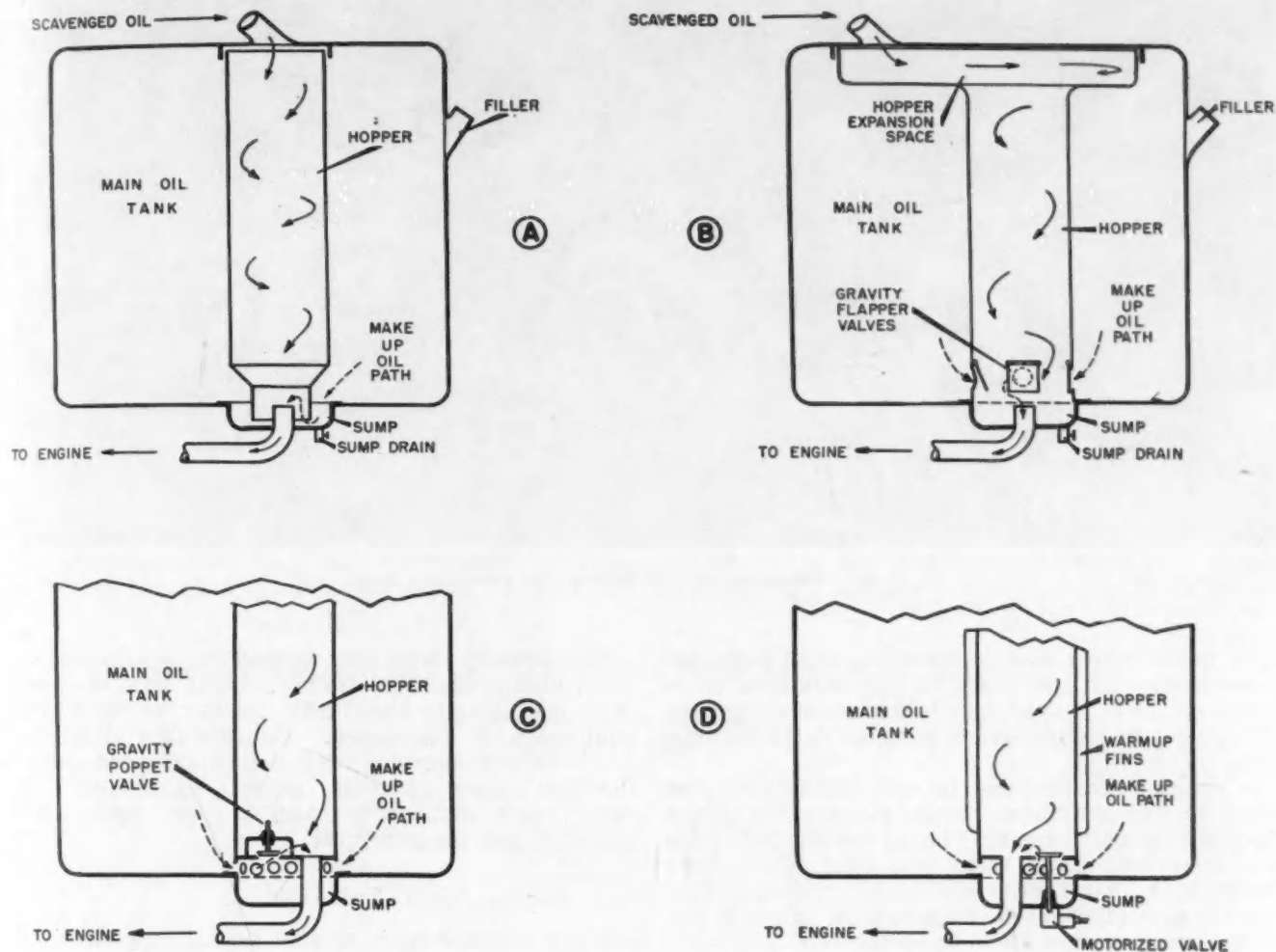
TO ENGINE ←

SUMP

MOTORIZED VALVE

Ⓓ

Fig. 3—Oil tank hopper and sump details: A, initial design; B, first improvement incorporating expansion space and flapper valves; C, poppet valve replacement of flapper valves; D, positive segregating hopper

industry. Engine starting has been successful and repeatedly accomplished in the laboratory at temperatures of −65F using high vapor pressure for fuels, and also at the minimum field temperature encountered of about −55F using similar special fuels.

Start Tests Continuing

Some cold starts, too numerically few for definite conclusions, have been successfully accomplished in the field in the temperature range of −40 to −50F using special high pressure priming systems and regular grade gasoline. Continued testing on this subject is presently under way and it is hoped that definite conclusions on this rather debatable method of starting will be forthcoming shortly.

Satisfactory and consistent dilution systems are not available on current aircraft and heat is still a basic low temperature operation requirement. When coordinated improvements are made in dilution systems and cold starting systems, installations will be provided on current aircraft for low temperature starting without heat. Ground heating equipment has improved greatly in the last few years and preflight heating procedures are considered normal. It must be remembered, however, that heating is time-consuming, requires considerable preparatory maintenance, additional equipment and fuel.

As USAF objectives regarding this subject, the following might be listed in order of importance:

● Dependable and consistent aircraft operation,

● Operational improvements should be secured by a minimum weight penalty, added installations, or additional complications,

● Minimize preflight and preparation time to conserve manpower, and

● Minimize additional supplies and equipment required to decrease the logistics problem.

Turbo-jet engine starting is quite different from that of reciprocating engines. Much positive data,
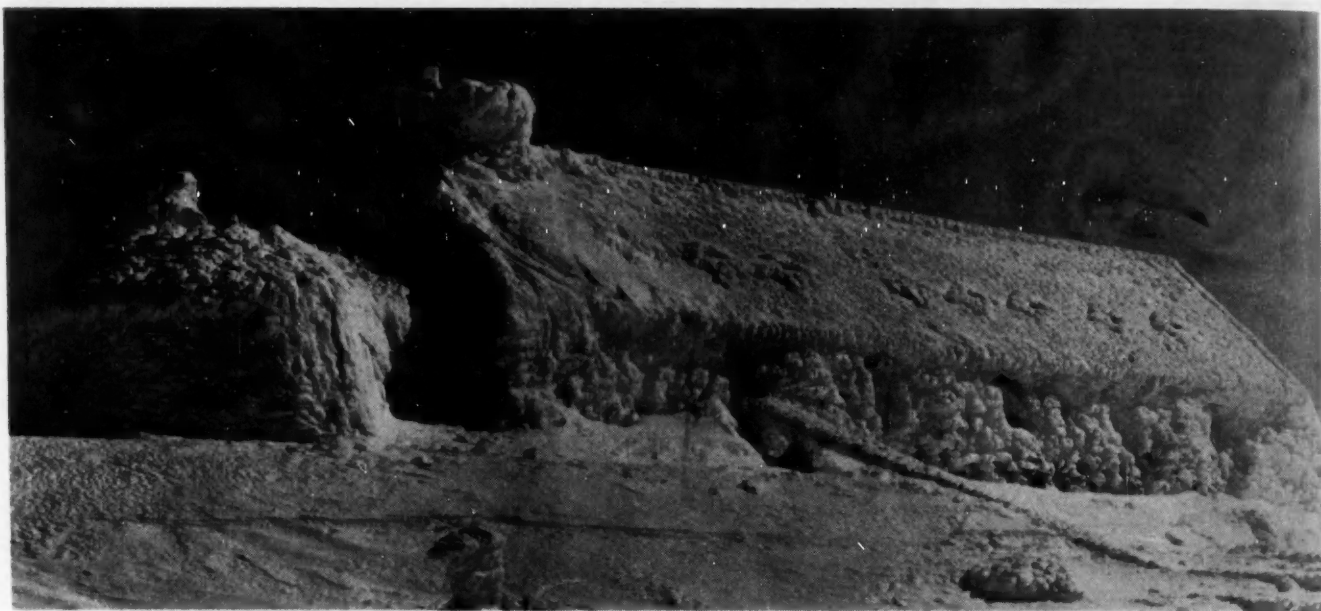
Fig. 4—Mt. Washington main test building after severe icing storm

both quantitative and qualitative, have been secured in the last two years. Tests have been completed on the J-31, J-33, and J-35 engines using both JP-1 fuel and regular grade gasoline down to temperature – 65F.

Jet engine starting can be satisfactorily started down to the minimum temperature limits using standard available fuels. The numerous tests continued at both Ladd Field and Eglin Field have shown that JP-1 fuel is not usable under normal operating conditions at temperatures much below 0F, if normal engine life is to be obtained.

In all these turbo-jet tests conducted to date, oil type AAF 3606 or AN-0-9, Grade 1010, has been used with satisfactory results. It has furthermore been shown that engine crankability is not a severe problem and can be successfully surmounted provided suitable external power sources are available.

Arctic experience has indicated that low temperatures adversely affect the operating characteristics of reciprocating engines. Rough operation and loss of power is commonly encountered particularly at low power cruise conditions.

Using Carburetor Heat

One of the most effective solutions to the problem has been the diligent use of carburetor heat. Substantial improvement in operation has resulted in many installations, but due to the lack of instrumented aircraft and suitable weather simultaneously, the Power Plant Laboratory has been unable to conclusively prove on a quantitative basis the effects of carburetor heat and/or variable cylinder head temperatures on the quality of engine operations for all existing installations.

There is insufficient data regarding the low temperature effects on engine operation for both direct fuel injection engines and also turbo-jet and turbo-prop engines. Here particularly, continued investigations seem in order.

Considerable emphasis is still to be placed on maintenance and accessibility. Many smaller problems still plague the USAF insofar as accessory equipment is concerned. Considerable difficulty and excessive maintenance is still experienced due to malfunctioning of seals, gaskets, grommets, 'O' rings, hoses, diaphragms, and so forth, when subjected to low temperatures.

Seals Leak

Many internal seals of fuel flow equipment still leak and cannot be corrected by normal maintenance. Hose connections and fittings plus gasketed surfaces all tend to leak due to cold flow. Other types of equipment having similar characteristics also present cold weather problems.

The Power Plant Laboratory is now concerned with four major low temperature test facilities. These are:

● Ladd Field, Alaska, where engine test stands for both reciprocating and turbo-jet engines are available for testing under actual Arctic conditions.

● The Power Plant Laboratories Low Temperature Building which has just begun operation and which is capable of providing controlled low temperature down to – 110F.

● Eglin Field's Climatic Hangar in which full size aircraft of the largest type can be ground operated under various climatic conditions, plus the Eglin Field Engine Test Cell where all types of engines can be operated throughout the power range under various climatic conditions.

● Mount Washington Icing Base where exceptionally severe natural icing conditions are obtained for at least six months of the year. Icing tests of particular value in induction system investigations can be conducted there, Fig. 4.

CRC

"Method of Operation" Details New Procedures

COORDINATING Research Council has issued a "CRC Method of Operation" which details an organization structure "designed to afford a straightforward method of accepting problems, carrying out the necessary work to obtain the answer, and distributing the resultant information to all those in-

terested." (SAE and API are the Sustaining Members of CRC.)

Important in the relatively new operational procedure is the Assignment Committee, which—reporting directly to the CRC Board of Directors—accepts, approves, and assigns projects . . . and acts as the

FUNCTIONAL CHART FOR COORDINATING RESEARCH COUNCIL, INC.

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    Committee
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    Committee
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Outboard Motors Manufacturers Association

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Automotive Research Committee
of the
American Petroleum Institute

MOTOR FUELS DIVISION

AVIATION FUELS DIVISION

DIESEL FUELS DIVISION

GROUPS AND PANELS

GROUPS AND PANELS

NOTE: This chart indicates that projects originating in either of the technical Committees, the Advisory Committee, or at the suggestion of outside organizations, are considered by the Assignment Committee and assigned to the appropriate technical Committee for carrying out the necessary work and for the preparation and issuance of reports.

coordinating agency between the Coordinating Fuel and Equipment Research Committee and the Coordinating Lubricants and Equipment Research Committee, the two groups through which CRC technical projects are accomplished.

The Assignment Committee now determines whether or not a project which has been proposed for Council activity will be supported by the cooperating equipment and petroleum industries with the necessary funds and personnel to carry on the work. . . . Chairmanned by the CRC President, its personnel consists of CRC officials concerned with both industry and technical aspects of the Council. (See accompanying chart.) As a result it is peculiarly adapted to considering all viewpoints in its functioning and, if a divergence arises between technical and industry viewpoints, to present "an opportunity for a thorough airing of the problem so that a common understanding may be attained."

Essential elements of the Assignment Committee are the Equipment Advisory Committees and the Petroleum Advisory Committee which have been established to represent the varied interests of the equipment cooperating industries. These Advisory Committees (see chart), shown connected by dotted lines to the Assignment Committee, advise the latter whether or not a project which has been proposed as a Council activity will be supported by the cooperating industries. The chairmen of these Equipment Advisory Committees sit as members of the Assign-

ment Committee.

Detailing qualifications for membership in CFR and CLR, the new document says: "The membership of the CFR and the CLR is selected from representatives of organizations which contribute adequate financial support, research facilities or technical data to the work of those committees, or persons who have training and experience of special value to the work of the committee." Such membership is subject to the approval of the appropriate committee and the Board of Directors.

Reports resulting from the work of the Divisions or Groups (established by CFR and CLR to carry out specific technical projects) are issued by the CFR and the CLR in the name of the Council, the "Method of Operation" points out. "In addition," it is stated, "these Committees act for the Council on reports resulting from the work of technical committees of other organizations in which the Council is participating. Where questions of policy regarding publication or distribution of a report from the CFR or CLR committee are involved, the report is submitted to the Board of Directors for decision."

Chairmen of the CFR and the CLR and their Divisions and Leaders of Groups are elected for a one year period by secret ballot.

Copies of the complete "CRC Method of Operation" are available on request from Coordinating Research Council, 30 Rockefeller Plaza, New York 20, N. Y.

Cites Airline Gains With Flying Boats

Based on paper by
CAPT. C. H. SCHILDHAUER, USNR (Ret.)

SEAPLANES hold potential economies for long-range, large-load air transport.

Flying boats are not limited by size and weight restrictions as are land aircraft. Increasing airplane size reduces direct operating costs per ton-mile.

Providing land airports for larger land planes may become prohibitive and curtail further increase in their size. Even with current large land aircraft, operators are faced with the problem of finding airports with adequate area, with runways of proper length and strength. Number of places in the world where a 250,000-lb land airplane can land is extremely limited. What happens when an airplane of this size is unable to make one of the widely distributed airports and has to land elsewhere?

No such limitations exist for seaplanes.

Additionally, the cost of building and maintaining airports to handle large land airplanes places a heavy burden on the air transport industry. Cost of major land airports in this country are in some cases close to the $50,000,-000 mark. Cost of equipping a seadrome is under $300,000.

While the Martin Mars type of flying boat was basically designed 10 years ago, material

SEAPLANE	LENGTH BEAM RATIO
MARS	6.66
MARTIN P5M-1	8.79
H.P.	10.00

Fig. 1—Trend in seaplane hull design. Third airplane shown is the High-Performance Seaplane under development, to be powered by four propeller turbines. It will have a gross weight of 360,000 lb

advances have been made during the last few years in bettering flying boat efficiency. Aerodynamic as well as hydrodynamic refinements have been made by increasing the length of hull-to-beam ratio, as shown in Fig. 1. With this gradual change, higher speeds reflecting more economical operation are in the offing. (Paper "Economical Aspects of Flying Boat Operation," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 7, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

BODY INTERIORS
Challenge Designers Anew

BASED ON PAPER BY

George W. Walker

Industrial Designer

AS an industrial designer, I see basic factors influencing the trend in interior design which I believe we should be thinking about.

Continued growth of woman's influence in buying cars is one of the most important of these trends. If you want to know what will sell, watch the woman. She knows what she wants, and she won't accept anything else.

Zipper-Equipped Upholstery

When she tries to turn her creative urge from her home to her car, she finds the same blues and grays and browns offered in car upholstery for 20 years. . . . They are men's colors. We are trying to sell Anna Held products in Lana Turner's time.

Why not let the customer, particularly the woman customer, pick out the interior color scheme she likes best . . . by designing interior fabrics of tailored rayon for quick change with zippers and push buttons?

The manufacturer spends $4 to $5 per yd at present for the necessary 15 yd of upholstery in a car. Then the buyer immediately conceals the $70 investment under $30 worth of seat covers. . . . The irony is that the $70 material won't wear one bit longer or better than plain duck at $1.50 per yd. So why not save the heavy original investment by adopting the quick-change, zipper idea?

By substituting duck for broadcloth, and giving the customer the color option of inexpensive nylon interiors, we can cut the price of the car. This is particularly commended for the new price jobs now being engineered. (Make no mistake about it, there will be one or more price cars with responsible backing on the market within months rather than years.)

Interior Room Adequate

Any design change which makes for greater adaptability, versatility and flexibility in the interiors is good.

* Paper "Car Interiors" was presented at SAE Detroit Section, Nov. 15, 1948. (Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

I believe we have, in modern cars, about as much interior room as we can expect. Cars don't need to be any longer . . . and they are about as wide as highway and garage limitations will permit.

But the buyer wants plenty of headroom both in front and in back. (Some of the volume cars went too far in cutting down rear head space for the sake of a tear-drop effect, and negative customer reaction is forcing them to go back up.)

Height of the body above street-level isn't too important if it is combined with proper exterior highlighting and the low silhouette.

Picture Windows

The motorist would like his car to be a picture window on wheels—like the picture windows we are putting into living rooms these days. . . . Let him and his passengers see in all directions, with no more obstructions than are necessary for structural support. (The bubble top of transparent plastic, I'm not so sure of. . . . It is gadgety.)

Free use of glass won't admit too much sun heat if we resort to heat-resisting glass where necessary. . . . As to the curved glass appearing in some new windshields, I'm for it! It is expensive, but offers offsetting benefits in vision and safety.

Seating Arrangement Ideas

As to seating arrangement, it has been suggested that the seating arrangement of a cockpit be adapted to the automobile, because it is more intimate and informal. Such an idea merits study, but many more people ride in buses and street cars more than in nautical cockpits . . . and on these vehicles the side seats are the last ones occupied. People want to ride forward . . . want to see where they are going.

The important thing is that we now have room to experiment. Instead of being compelled to stick to the single carriage seat in the rear, we can provide individual seats with individual adjustments for leg room and floor height. We can study the adjustable back arrangement of the Pullman chair.

TESTING
for Piston-

EFFECT of oils on piston-ring sticking in engines of personal airplanes is obscure. For this reason a test program was established to evaluate lubricants from this standpoint.

Test equipment for this investigation was adapted to a conventional propeller cell test stand. An auxiliary blower with measuring orifice was used for cooling air supply. The engine is enclosed in a cowl which incorporates a surge chamber and provides a means for controlling the cooling air flow. This system isolates the engine from the propeller air blast to satisfy the requirement of controlling cylinder head temperatures by means of controlled cooling air flow during the test run.

The engine used for these tests was an A-65 Continental 4-cyl, horizontally-opposed, aircooled aircraft engine, rated at 65 hp, at 2300 rpm. The cylinders were provided with complete baffles for both the head and barrel. Air flow was directed upwards from the bottom of the engine. The baffles had inlets and outlets of equal spacing equivalent to about 1.5 times the fin depth.

Special compartments for each individual cylinder head and each individual cylinder barrel were provided on the outlet side (under the cowl top) with cooling air damper controls, located in the cowl cover. Thus, the temperature of each cylinder could be varied independently from the others making it practical to maintain uniform temperature limits for all cylinders. The engine installation arrangement is shown in Fig. 1.

Past experience indicated the necessity for rather complete temperature information from each cylinder. The cylinder head, upper ring travel, and oil temperatures would have to be determined and controlled during a given test so that results could be correlated with subsequent tests.

All cylinders were equipped with top and bottom spark-plug gasket thermocouples, top and bottom upper ring travel thermocouples, and top and bottom cylinder flange thermocouples. In addition, No. 1 cylinder had top and bottom lower head fin thermocouples for additional data on temperature gradient. The location and method of installation of the thermocouples are shown in Fig. 2.

In addition to temperature data, measurements were made of cooling air distribution to the cylinders. Static pressure probes were located in the cowl cylinders 1 and 2. Similarly, temperature measurements were made of the cooling air below the cylinders and in the cylinder head compartment above each cylinder.

A special oil screen adapter was used to carry the oil from the engine oil pump through an external heat exchanger before passage through the engine. Both steam and water were piped to the exchanger to permit close temperature control. Oil temperature was measured at the inlet to the engine oil galleries.

Carburetor air was taken from the test cell through a standard aircraft air scoop and hence the temperature and pressure was not controlled.

It was necessary to have a test severe enough to

EXCERPTS FROM PAPER* BY

James E. Champion

Field Engineer, Continental Motors Corp.

cause piston-ring sticking in a reasonable period of time, which we considered to be 50 hr or less. It was not practical to run for hundreds of hours to obtain an answer to a problem of this nature. Consequently, the running schedule was established at full throttle and 2300 rpm for all runs, with temperatures controlled to values determined by the time required to induce piston-ring sticking.

To establish the temperature reference line, the first test was run with an oil of known field performance. In the initial run, the conditions set up were too severe and temperatures well over practical limits were obtained. Hence the length of the run was less than 10 endurance hours.

Finally the temperature limits were revised for this base line test as follows: upper ring travel temperatures of 450F, ±10, with the spark plug gasket temperatures at 550F, ±10, at the hottest point regardless of whether it was top or bottom of the
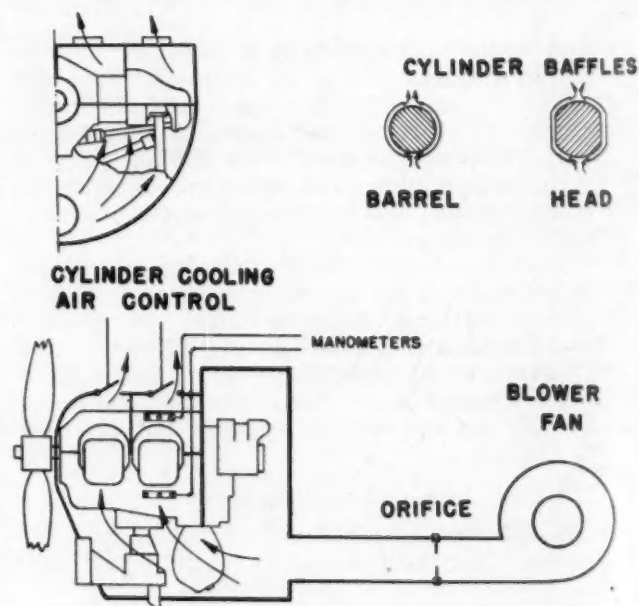

Fig. 1—The A-65 Continental 4-cyl engine installation for evaluating effects of oils on piston-ring sticking

Plane Engine Oil Ring Sticking

cylinder. The flanges were allowed to run around 300F without trying to establish any limits, since the flange temperature was unduly influenced by crankcase temperature in this installation. The oil temperature was established at 220 to 225F.

With these limits and using the established reference oil, piston-ring sticking occurred in about 26 hr of engine test time. Although the temperature limits appear to be rather wide, good correlation between successive runs was obtained. For instance, in rechecking a run on the base line oil, ring sticking was found to start within approximately 2 hr of the original run.

The main indication of ring sticking during a test is the increase in crankcase pressure. Typical crankcase pressure versus time is plotted in Fig. 3. This curve is shown in comparison with the temperature data that is recorded for a typical cylinder. Some scoring of pistons occurred before the tech-

nique of interpreting the various changes in pressures was developed.

In the beginning, it was difficult to know whether the increase in crankcase pressure was caused by blow-by from one cylinder or from all four. However, by correlating changes in cooling-air pressure drop across the cylinders (to maintain constant upper ring travel temperature), it was possible to determine which cylinder was contributing to increased blow-by and hence was experiencing piston ring sticking.

Between tests, in rebuilding the engine, new cylinders or completely remanufactured cylinders in new condition were used. Each engine build-up included remanufactured rods, new rod bearings, and new main bearings as well as new spark plugs. The new rings and pistons used had the piston-ring side clearance maintained between the low limit and plus 0.0005. That point is quite important, especially on the two top rings, if correlation of results is to be obtained.

This series of tests covered approximately 20 different samples of oil submitted by several different oil producers. The samples included both mineral-base oils and compounded oils with additives. The total spread in piston-ring sticking endurance was quite large. Some oils ran from 5 times as long as others. Yet this, in itself, is not the complete criterion for selection, since some of the long endurance oils created difficulties in the engine by forming deposits on the spark plugs and accumulating an undesirable ash in suspension.

Our evaluation of the engine after test was concerned with cylinder and piston wear, degree of piston-ring sticking, and engine deposits in general, particularly in the piston, rocker boxes, and on the valve stems. All bronze parts and bearings were of interest from the standpoint of any adverse effect caused by additives to the oil.
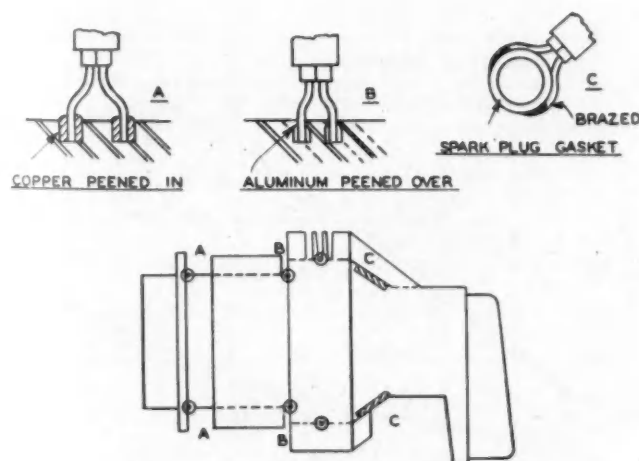

Fig. 2—How cylinder thermocouples were installed on the Continental A-65 engine to get data on temperature gradient
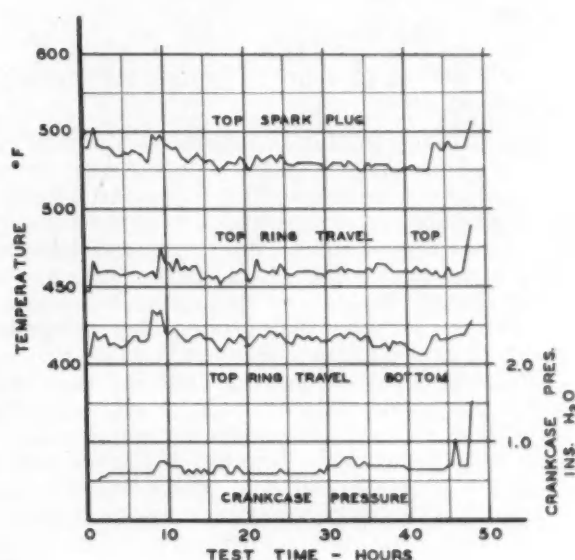

Fig. 3—Temperature data and crankcase pressure readings for a typical cylinder. Increase in crankcase pressure during the test indicates ring sticking

Survey of ENGINE POWER

BASED ON PAPER* BY

H. T. Mueller
and K. L. Pfundstein

ETHYL CORP.

POWER loss variations in comparable engines appear to hinge on degree of design know-how and the compromise made in selecting component and design combinations, a survey of truck, bus, and tractor engine makers indicates. While it is not possible to account for specific variations in each type of power loss, we can report what they are and the factors affecting these losses.

Total power losses of an engine are made up of friction of internal moving parts together with pumping losses and power requirements of driven accessories. Internal engine losses break down into two categories: (1) mechanical friction due to rubbing and moving parts such as bearings and piston rings, and (2) pumping losses from work done in drawing air into the engine through the induction system and in expelling exhaust gases through the exhaust system.

Actual performance of a journal bearing can be closely approximated by theoretical predictions. An important relationship has been evolved in this expression:

$$f = ZN/P$$

where:

   f = coefficient of friction,
   Z = absolute viscosity of the lubricant,
   N = Journal rpm, and
   P = bearing pressure in pounds per square inch of projected area.

Fig. 1 shows the type of curve obtained by plotting observed coefficients of friction, for a given bearing, against their corresponding values of ZN/P. Bearings of different geometrical proportions will have their own characteristic curves, but all will be similarly shaped. Coefficient of friction also depends on such design factors as the length-diameter and clearance-diameter ratios since they affect bearing pressure and oil film thickness.

Material combinations do not affect the coefficient of friction above critical ZN/P values. But they are important from other considerations, such as their ability to operate in the region of partial lubrication during engine starting and break-in.
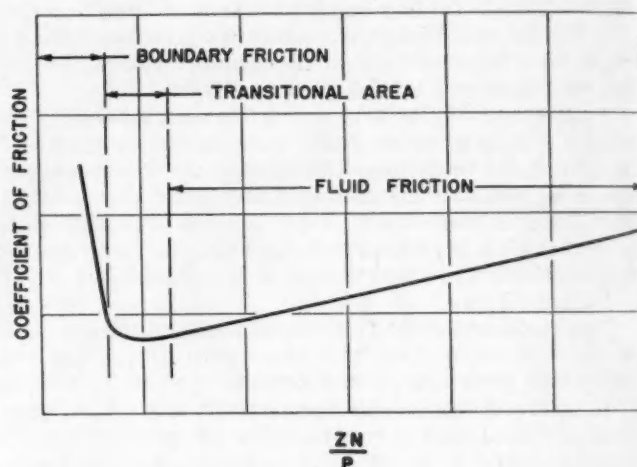
Some bearing performance problems seem to stem

Fig. 1—Typical variation of friction coefficient with the value ZN/P for a journal bearing
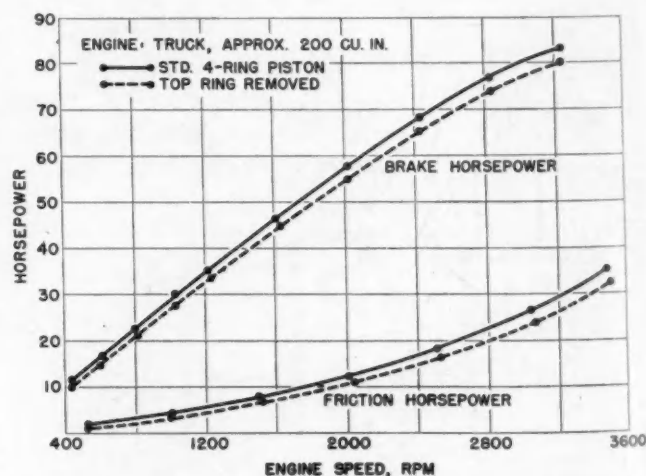

Fig. 2—Removing the top piston rings in this truck engine lowered both friction and brake horsepower. But it is felt that if properly designed, the three-ring combination would gain on friction horsepower without hurting performance
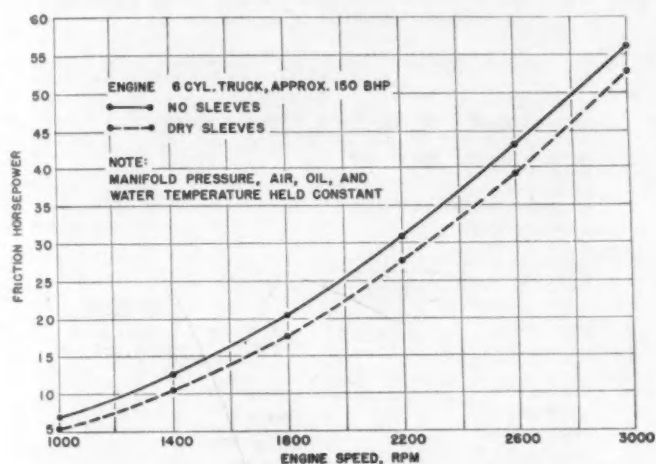
LOSSES REPORTED

Fig. 3—Cylinder sleeves, these data show, reduce friction horsepower. Explanation for this is that with sleeves, heat transfer is lowered so that wall temperature rises which lowers oil film viscosity
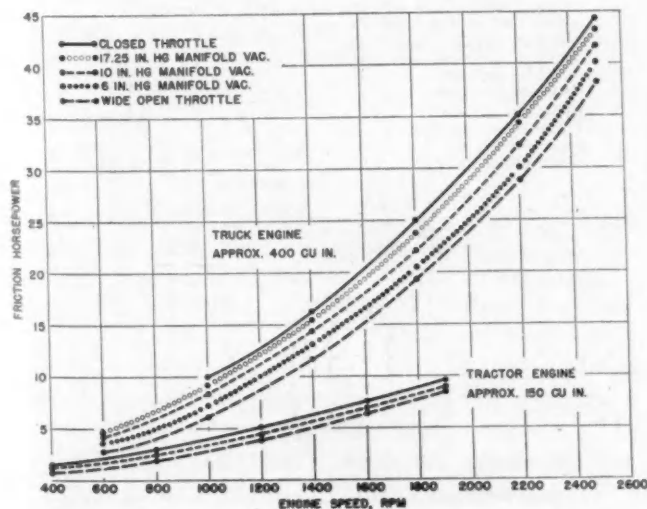

Fig. 4—Effect of throttle opening on friction horsepower

from rigidity of the engine's structure and components related to bearings. Obviously they must be resolved together to minimize bearing-friction power losses.

Theoretically piston and ring friction, the second type of mechanical friction, could be reduced by:

1. Reducing rubbing area of the piston wall to diminish the area of oil film in shear.

2. Using maximum piston clearance to increase oil film to reduce scuffing.

3. Holding to a minimum ring load, number of rings, and width of rings.

But application of these measures may become impractical when design requirements add characteristics such as specified engine output, maximum service life, low oil consumption, and minimum blowby.

Fig. 2 demonstrates the effect of reducing engine friction by removing the top ring of a four-ring combination piston. In this case the friction reduction gained was offset by about an equivalent loss in engine output. Here it is felt that blowby caused the power reduction since compression pressures were appreciably lowered with increase in blowby rate. It also was said that a properly designed three-ring piston assembly probably would not have been as objectionable performancewise.

Fig. 3 illustrates the difference in friction horsepower between a certain engine's operation with and without cylinder sleeves. The lower level obtained with the sleeves probably comes from a lower heat transfer to the jacket water; this raised the wall temperature level and lowered lube film viscosity.

Another item intimately related to piston and ring design is cylinder bore distortion, from either mechanical or thermal stresses. It very largely determines behavior of any piston and ring combination.

Second part of internal engine losses, pumping losses, are the total work required both to draw a fresh charge into the cylinder and to expel exhaust products. Any flow restrictions in either the induction or exhaust systems affect these losses. The combination of valve timing, valve life, inlet and exhaust passage design, carburetor, air cleaner, and muffler systems determine the total restrictions. Losses vary with such operating conditions as engine speed and throttle opening, as shown in Fig. 4 for a 400-cu in. truck engine and a 150-cu in. tractor engine.

Changing suction pressure toward the atmos-

pheric level reduces pumping losses to a greater extent than a corresponding reduction in exhaust back pressure. Such measures improve bmep by increasing volumetric efficiency as well as reducing pumping losses.

Effect of compression ratio on friction mean effective pressure for two truck engines is shown in Fig. 5. For a change of nearly two compression ratios on the 150-hp engine, effect on fmep is considerably less than for a one compression-ratio change on the 115-hp engine.

Theoretically, higher pressures in the cylinder cause fmep to go up with compression ratio increase. But probably the wide differences between these two engines stem partly from the greater distortion in the 115-hp engine. Power output comparisons evidenced this. Engine No. 1 improved as per theoretical expectations for the compression-ratio increase; engine No. 2 fell far short, despite no altering of volumetric efficiency.

Accessory power losses can be separated into those for fixed accessories (such as air cleaners, carburetors, and mufflers), and those for engine-driven accessories (such as fans, generators, and pumps).

Fixed accessories are related to power losses.

How fixed accessories affect quantitative and qualitative delivery of fuel and air to the engine determines their part in power losses. Air cleaner and muffler systems may have low restriction characteristics; but because of their nonresonant effect, they actually may reduce the mixture quantity supplied certain cylinders, or alter fuel nozzle flow and thereby produce wide instantaneous variations in air-fuel ratio.

Correct Adjustments Advocated

Properly tuning these systems minimizes these disorders. Additionally volumetric efficiency then approaches the limit set by engine dimensional factors. Since engine speed affects resonance requirements, compromises must be made for engines operating over a wide speed range. Tractor engines, operating within a reasonably narrow range, allow a better compromise.

Figs. 6 and 7 picture air cleaner and muffler losses for tractor and truck engines over a wide displacement range. Note that all engines are divided into groups I, II, III, and IV. These groups were arbitrarily selected on an engine speed basis. Tractor engines with governed speeds within these respective groups are compared with truck engine data obtained at the mean speed of each group.

Other important considerations in accessory loss comparisons are engine displacement and speed relationships. But the tractor group submitted most of the accessory loss data at governed speed only. It was necessary to use this method of presentation to get comparisons on a displacement and speed basis as well as to mask the identity of the tractor engines. Since losses shown vary only slightly over the narrow chosen speed range, comparisons between engines within a group are reasonably firm.

Fig. 6, showing air cleaner losses, reveals very little difference between tractor engines within a given displacement range for any speed group. But effects of speed range and displacement appear to be ran-
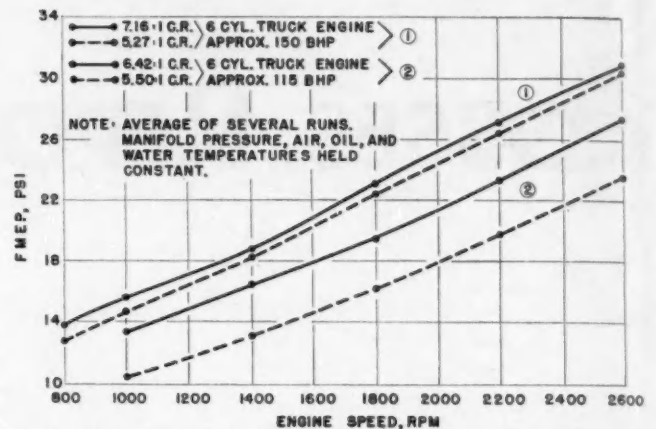
Fig. 5—Tests from which these results were obtained show that effect of compression ratio on fmep may differ from predictions because of other factors. Big difference in fmep increase between engines No. 1 and No. 2 due to compression ratio increase stems partly from the greater distortion in engine No. 2
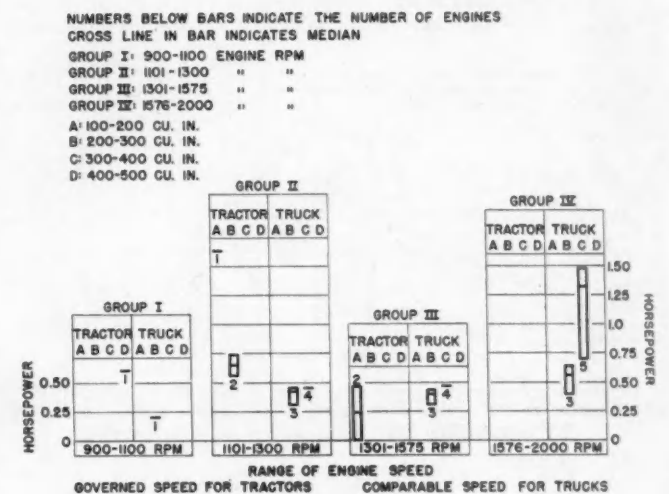
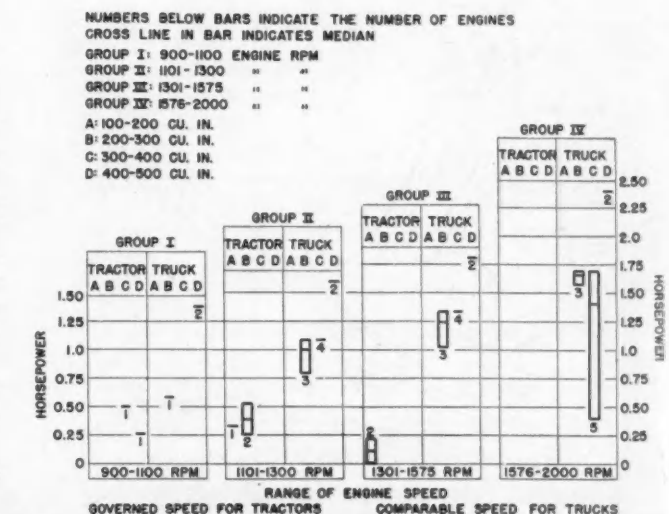Fig. 6—Air cleaner losses for truck and tractor engines

Fig. 7—Muffler losses are small for tractor engines. For truck engines, they increase with speed and displacement
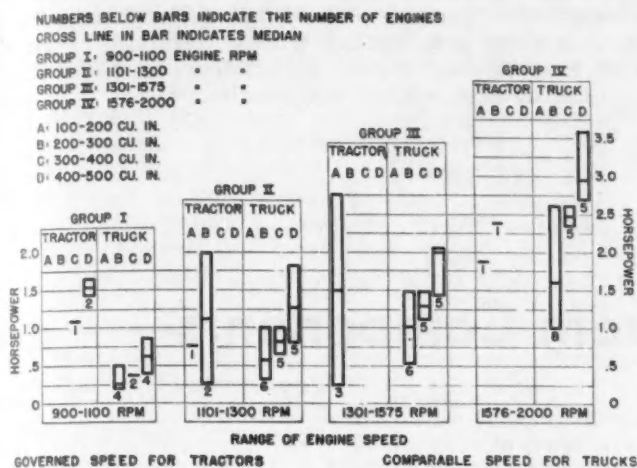
NUMBERS BELOW BARS INDICATE THE NUMBER OF ENGINES
CROSS LINE IN BAR INDICATES MEDIAN
GROUP I: 900-1100 ENGINE RPM
GROUP II: 1101-1300   "   "
GROUP III: 1301-1575   "   "
GROUP IV: 1576-2000   "   "

A: 100-200 CU. IN.
B: 200-300 CU. IN.
C: 300-400 CU. IN.
D: 400-500 CU. IN.

Fig. 8—Fan losses for tractor and truck engines

NUMBERS BELOW BARS INDICATE THE NUMBER OF ENGINES
CROSS LINE IN BAR INDICATES MEDIAN
GROUP I: 900-1100 ENGINE RPM
GROUP II: 1101-1300   "   "
GROUP III: 1301-1575   "   "
GROUP IV: 1576-2000   "   "

A: 100-200 CU. IN.
B: 200-300 CU. IN.
C: 300-400 CU. IN.
D: 400-500 CU. IN.

Fig. 9—Total power losses rise with displacement for any group of truck or tractor engines

Fig. 10—Total friction mean effective pressure at governed speeds of tractor and truck engines

from the power required to drive them. Fig. 8 shows fan losses for tractor and truck engines. Same scheme was used here as for air cleaners and mufflers. For both tractor and truck engines, there is a trend of increased loss for respective engine sizes as displacement increases. This follows general expectations.

But there is a wide variation between the lowest and highest tractor engine in Group II, column B, and Group III, column A. In fact these differences are greater than any other variation in Fig. 8.

Survey data for tractor engines show that power losses due to generators vary from 0.1 to 0.5 hp and are independent of engine size and speed. Charging rate the data represents is not known in most cases. But even the highest loss reported may not be out of line with considerations of possible electrical load requirements.

Truck engine generator data are not considered here because generator size selected depends on type of vehicle in which the engine is installed.

Fig. 9 shows total power losses of the tractor and truck engines surveyed. For any group of tractor or truck engines, total power losses go up as displacement increases. For truck engines of similar displacement, total power losses rise progressively as engine speed increases. These trends are in line with general expectation. However, the tractor data show an inconsistent trend with regard to speed.

Rather than comparing tractor and truck engines at comparable speeds, Fig. 10 shows total friction mean effective pressure relationships based on governed speeds.

Engines are grouped according to displacement. Note the general trend of increased fmep as engine displacement goes down. Yet Fig. 9 shows a reverse trend on a friction horsepower basis. Evidently

dom. Apparently magnitude of air cleaner losses is small for tractor engines surveyed, except for the relatively high loss shown for the one engine in Group II, column A. As expected, values for truck engines tend to increase with speed and displacement.

Muffler losses, shown in Fig. 7, also are small for tractor engines. Again speed and displacement vary. And there is little difference between tractor engines within a given displacement range. Truck engines exhibit the same general trend of increasing loss with speed and displacement.

Losses from engine-driven accessories stem only

total friction losses are proportionately higher for smaller engines. Reason for this is that neither size of some accessories nor amount of internal friction scale down directly with decrease in engine displacement.

On an industrywide basis it seems that all engine makers are "reading out of the same book," although they are getting widely different results. This may be due to both design technique and the manner of determining end results.

Reducing Losses From Components

Factors influencing power consumption of engine components and accessories and ways of minimizing these losses are here discussed by specialists in design of these parts.

Pistons and Rings

by A. M. Brenneke
Perfect Circle Corp.

Few engines can afford to reduce friction at the expense of cylinder and ring wear rate. Chrome plate does offer a possible means of maintaining present wear rate and reducing friction or maintaining present friction and reducing wear rate.

Theoretically, a reduction in friction due to the lower coefficient of chrome exists too; but advertising not withstanding, we have not been able to measure it. Perhaps piston rings do know about fluid friction after all. We must warn that without considering wear rates, compression ring widths of less than 3/32 in. cannot be recommended for four-cycle engines. At the present state of the art, oil control and resistance to sticking are very poor with lesser widths.

by Stuart Nixon
Sealed Power Corp.

To reduce friction any appreciable amount, it is necessary to: (1) minimize scuffing, (2) maintain oil film thickness, (3) reduce static friction, and (4) reduce oil shearing force.

Using wide piston clearance and few narrow rings minimizes friction. But this combination is not conducive to long life. And piston and ring life are prime requirements for a tractor.

Ring load desired is one that gives lowest total load and best oil control. In general, reducing ring tension effects oil control considerably. Any gain in reducing ring load may be at the cost of oil control.

Narrow rings obtain most consistent results. With such rings total load is kept low, but unit pressure is maintained. Use of fewer wide rings than narrow rings to keep ring load constant invariably results in poorer oil control. A narrow ring reduces starting force required at the dead centers.

Actual number of rings contributes to ring friction. Each ring over two adds about ½ to ¾% to total friction. This is one of the penalties to be paid for satisfactory engine life. Also there is apparently a low limit on ring width after which things begin to happen. Ring resistance to abrasive wear increases or stays equal as ring width decreases, down to a diameter-to-width ratio of about 40. Rings with narrower ratios have evidenced less resistance to wear. This may be entirely a function of piston design or ring arrangement that has not been worked out yet.

Other power loss involving rings and piston is the shearing of the oil film. Engines running with close piston clearance (thin lubrication films) indicate a higher friction loss than engines operating with a wider clearance.

Oil viscosity at the operating temperature enters into this shearing loss. Force required to shear the film is inversely proportional to film thickness and directly proportional to coefficient of viscosity. Lowering viscosity runs the danger of weak film strength at elevated temperatures and higher oil consumption.

Fans and Water Pumps

by K. A. Beier
Schwitzer-Cummins Co.

Radiator and fan combination must be worked out together. A good radiator with a badly chosen fan, or vice versa, will do a poor job.

Shrouding the fan has been given very little attention because it was the general belief that little can be gained by the additional expenditure for the shroud. Yet we have cases where we nearly doubled air delivery of certain fans by addition of a shroud.

It is equally important that the engine designer

have a clear picture of what it means in power expenditure to lower the air to boil differential below a given figure. He wants to be sure that his engine cools properly under extreme conditions, which may happen only a few days during the year's operation. He forgets that the user is penalized for this safeguard during the entire operating period.

Not so long ago it was entirely satisfactory if the engine would not boil when the ambient temperature was 100F. Today we are asked to cool to 110 to 115F; this means in many cases that air flow through the radiator must be increased from 40 to 60%.

It can easily be calculated what it costs the user of the vehicle to expend an additional two or three unnecessary horsepower on a tractor fan during a season. This figure should be the best argument for the designer with the sales department for any slight additional cost to proportion and design properly both radiator and fan.

The water pump comes in for the same argument. Because of either design limitations or final cost, pumps, in the last few years, have assumed the form of a paddle wheel in a nondescript housing. In several cases we have been able to raise pump efficiency—through research of individual applications—so as to actually halve horsepower. These savings are worthwhile when we consider that there are pumps in the field today that take as much as 6 to 8 hp.

Bearings

by A. B. Willi, Jr.
Federal-Mogul Corp.

Design factors play a role in the power consumed by bearings.

For example, the ZN/P factor indicates two things —friction coefficient and oil film thickness. From a friction standpoint, a low ZN/P value seems desirable; but as this factor decreases, so does oil film thickness. Film thickness may become so minute that surface irregularities on bearing or shaft may partially rupture the oil film and result in metal-to-metal contact, with a terrific increase in friction loss.

Theoretically, the minimum oil film thickness must exceed 0.00004 in. to remain within the fluid friction range. For the average tractor engine, average ZN/P for connecting rod bearings is about 22, with an average minimum oil film thickness of 0.0001 in. Calculated thinness of this film points up the need for maintaining good shaft and bearing finishes and clean engines, if friction losses are to be minimized.

Next recommendation is the use of light viscosity oils. For example, with all other factors affecting power loss remaining constant, use of SAE 40 oil instead of SAE 30 showed a 13% increase in calculated bearing power loss in a specific engine. This should not be taken as a general recommendation, for with heavily-loaded engines using a lower viscosity oil may make the oil film dangerously thin.

Though most sleeve bearings can operate fairly well through a wide oil clearance range, there is a rather narrow clearance band at which they function more efficiently. As oil clearance increases, so does oil flow; and its additional cooling effect reduces oil film temperature which raises viscosity.

Several engines investigated showed a power loss increase of 15 to 18% when oil clearance was opened up 0.0015 in. For this reason it may be well to set up bearing fits initially at the absolute minimum oil clearance at which they will operate, and hold overall oil clearance tolerance to as close limits as is economically possible.

This would require a minimum oil clearance of about 0.0003 to 0.0004 in. per inch of shaft diameter, with 0.0005 in. tolerance on shaft and case bore diameters and 0.00025 in. tolerance on bearing wall thickness. These limits are about 50% better than those now being held on most tractor engines, but are about the same as those now being used on some passenger car engines.

Obviously bearing length-to-diameter ratios also are worth considering when looking for ways to reduce bearing friction losses. Many tractor engine bearings examined are well proportioned and have ratios of 0.4 to 0.6 for rod bearings, and 0.6 to 0.8 for main bearings. But a fair percentage of bearings have ratios exceeding one. Such bearings should be redesigned because of their inefficiency.

Their power loss is more because of the greater area of oil film that is being sheared. Such bearings tend to run hotter; to keep their temperatures within reasonable limits, greater clearances must be allowed to increase oil flow, which gives still more oil to shear and still more power loss.

Taking all bearings and bushings into consideration (rods, mains, and camshaft bearings, piston pin, water pump, generator, distributor or magneto bushings), it seems that overall bearing friction losses do not exceed 2 to 2½% of the rated engine power.

Air Cleaners

by W. W. Lowther
Donaldson Co., Inc.

Greatest gains may be made by paying attention to those items requiring the greatest horsepower. But this does not mean that paying attention to the induction system and improving volumetric efficiency of the engine cannot boost horsepower output.

Our tests show that horsepower output of a tractor engine is directly proportional to the actual air demand of the engine. We have data which indicate that the horsepower output of a certain tractor engine has been increased about 5% by paying attention to the air ram of a proper length of stack and resonance of the induction system, together with proper valve timing, manifold design, carburetion, and ignition.

Fig. 1—Approximate dimensions of simulated ice buildup on Curtiss 89301-15 propeller blades
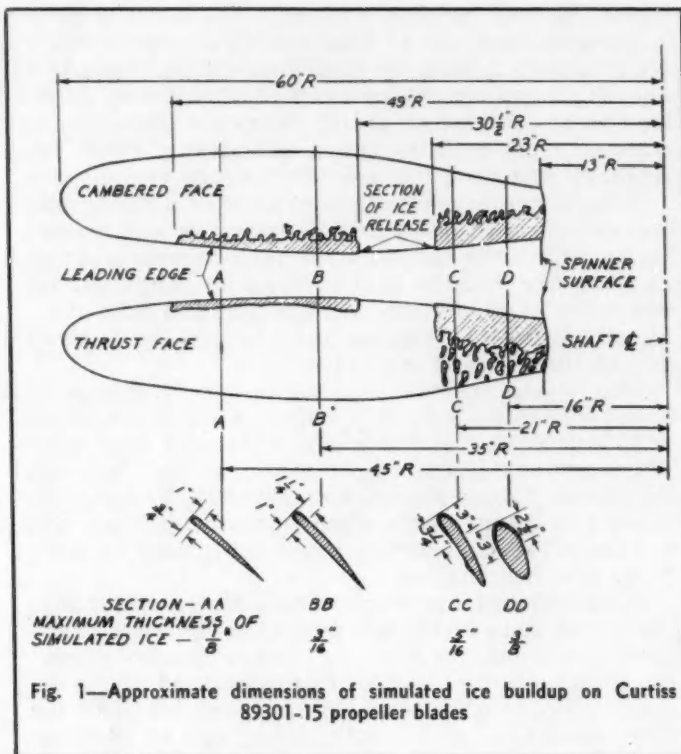
Heated-Air

(This paper will be printed in full in SAE Quarterly Transactions.)

A HEATED-AIR thermal anti-icing system for propellers costs a little less in propeller aerodynamic efficiency than a moderate ice accretion. Both reduce propeller efficiency only a few per cent in the usual operating range.

NACA tests of a propeller with moderate ice accretion show a 3% loss in efficiency for operation in cruise or gentle climb. Losses under severe conditions may be greater; for a highly loaded propeller in steep climb where ice causes premature stalling, loss in efficiency has been calculated to be 15% or more.

Tests of a heated-air thermal anti-icing system indicate that it can be applied continuously with only a 1% loss in aerodynamic efficiency. About half the loss with this system is due to the drag of the nozzles required at the blade tips. The remainder is due to aerodynamic losses in the internal flow. Heating the internal air seems to have little effect on propeller efficiency.

These conclusions stem from three investigations conducted in the NACA 16-ft high-speed wing tunnel at Langley Field to establish the relative magnitudes of propeller efficiency loss due to ice formation and to one type of anti-icing system. First, effect on propeller characteristics of a simulated ice deposit was measured. Then propeller efficiency loss was determined with nonheated air in an idealized heated-air type system and with nonheated and heated air in a complete heated-air anti-icing system.

For the investigation of iced propellers, photographs were obtained of propellers operating in flight under icing conditions. They showed a heavy deposit of ice on the blade shanks, lighter deposits on the middle portion of the blades, ice-free blade tips, and just outboard of the shanks a section of ice release. Cement and fabric were arranged on propeller blades to simulate typical ice accretions in shape, location, and roughness. Fig. 1 is a sketch of the propeller blades with the simulated ice.

The blades were of the Curtiss 89301-15 design, which embodies Clark Y-sections and has an activity factor of 98 per blade. The propeller had three blades and was 10 ft in diameter.

The coated propeller was tested at a constant rotational speed of 1800 rpm over a representative range of blade angles and values of advance ratio. Then the coating was removed, and the tests repeated.

Comparison of the two sets of test results showed
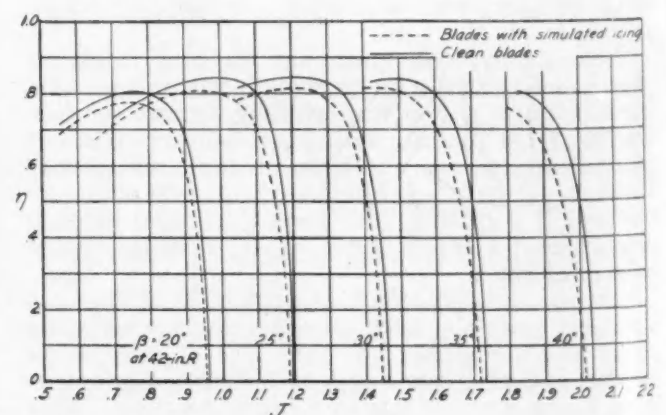
Fig. 2—Effect of icing on propeller efficiency of 10-ft diameter propeller. (J is advance ratio)

Anti-Icing Cuts η_{prop}
Less than Moderate Icing

BASED ON PAPER* BY

Blake W. Corson, Jr.

National Advisory Committee for Aeronautics

that the simulated ice reduced thrust more than it reduced power required to operate at a given condition. At high values of the power-rotational speed cubed ratio, the reduction in thrust is apparently due to loss of lift of the blade section. At very low values of the power-speed cubed ratio, the simulated ice evidentally increased markedly the drag of the blade sections near zero lift.

Fig. 2 shows propeller efficiency as a function of advance ratio (velocity of advance divided by the product of propeller rotational speed and propeller diameter). Propeller efficiency peaks at about 83% for medium blade angles. The simulated ice reduces peak efficiencies about 3%. The loss remains only about 3% for all blade angles in the regions of advance ratio less than that for peak efficiency. (Portions of the curves at values of advance ratio higher than those for peak efficiency are not representative operating ranges for propellers because they represent conditions of extremely light loading.)

The difference between the envelopes of the efficiency curves, as plotted in Fig. 3, varies from 2 to 3%.

Because the 2000-hp electric dynamometer used to drive the propeller was inadequate powerwise for determining stalling characteristics of the propeller, the stalling condition was investigated analytically. This served two purposes: It showed that the calculated decrease in propeller efficiency was of the same magnitude as that found experimentally, in the range where experimentation was possible. It gave an indication of the detrimental effect of

premature stalling of iced blades on propeller efficiency.

The airfoil data used for the analysis were taken from a study of the effects of a simulated ice formation on the aerodynamic characteristics of an NACA 0012 airfoil. The effect of the ice was to reduce maximum lift greatly and to increase the drag, so that values of lift-drag ratio for the iced wing were less than half those for the ice-free wing.

Propeller characteristics were calculated for a blade angle of 30 deg for both the clean propeller and the iced propeller. The assumed propeller was shaped like that used for the wind-tunnel tests, except that the blades were of NACA 0012 section and the ice was assumed to be evenly distributed over the leading edge of the propeller blades from hub to tip.

Calculated values of efficiency shown in Fig. 4, agreed quite well with experimental results. According to the calculations, icing reduces peak propeller efficiencies about 5%—which compares with the measured reduction of 3%—in the representative operating range.

But ice may cause the propeller to stall prematurely, the calculations indicate, with a resulting large loss in efficiency. In the range of advance ratio corresponding to steep climb, an iced propeller might operate in a stalled condition that would reduce propeller efficiency 15%.
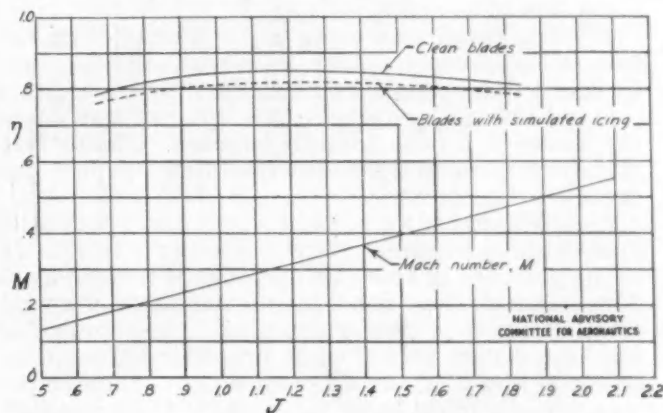
Fig. 3—Comparison of envelope propeller efficiencies to show effect of icing
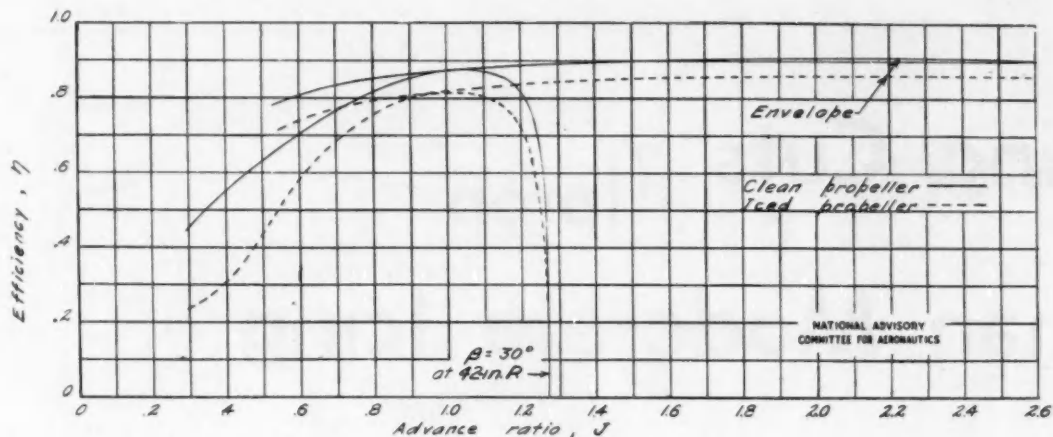
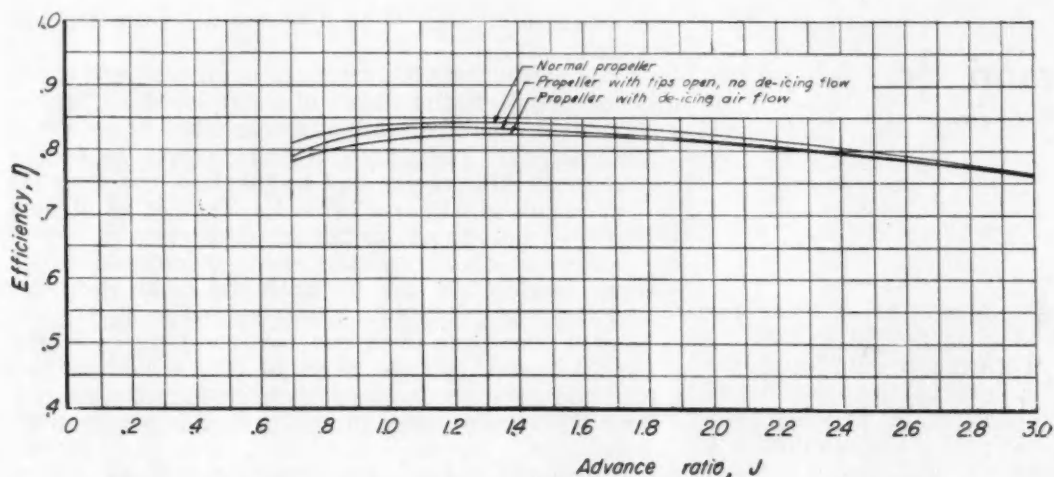Fig. 4—Envelope curves of calculated propeller efficiency

Fig. 5—Comparison of envelope curves of propeller efficiency for idealized setup

The alternative to propeller ice accretions is propeller deicing or anti-icing. Keeping ice from the blades by ducting heated air through hollow metal blades—and the other ice-removal or prevention schemes of electrically heated boots and dissolution by antifreeze fed by slinger ring and boots—entails some loss of propeller efficiency.

For heated-air anti-icing, air is ducted from the free stream, heated either in a heat exchanger or by direct combustion, and passed through a gland into the rotating propeller. The internal flow heats the blades as it flows radially outward. Finally it is discarded through nozzles at the blade tips into the propeller slipstream.

An idealized heated-air anti-icing setup, was used first to study propeller efficiency losses attributable to the presence of blade tip openings and to internal flow. The air was not heated, and there were no rotating seals or heat exchangers. The propeller was tested first as a normal propeller with no tip openings and with the air inlet sealed. Then openings were cut in the blade tips and the tests repeated with the air inlet still sealed. A third series of tests was made with the air inlet open and the air flowing internally through the propeller. Each configuration was tested at eight values of blade angle.

Fig. 5 compares the envelope efficiencies obtained with the three configurations. For the unaltered propeller, the efficiency level for normal operation was above 80% and peaked at about 84%. When openings were made in the blade tips and the propeller tested without internal airflow, the efficiency loss due to the presence of the tip openings was found to be about 1.5% at the lower values of advance ratio and about 0.5% at high values. Internal airflow produced a further decrease in efficiency. A comparison of the top and bottom curves in Fig. 5 shows that the overall efficiency loss varied from about 3% at low values of advance ratio to 0.5% at an advance ratio of 3.0.

The two obvious sources of aerodynamic loss entailed in this system are the loss due to the drag increase of the propeller blade tip sections caused by the presence of the air exit nozzle and the loss due to friction and turbulance in the internal flow.

The experimental investigation and subsequent analysis showed that size of the blade tip openings should be no larger than the mass flow demands
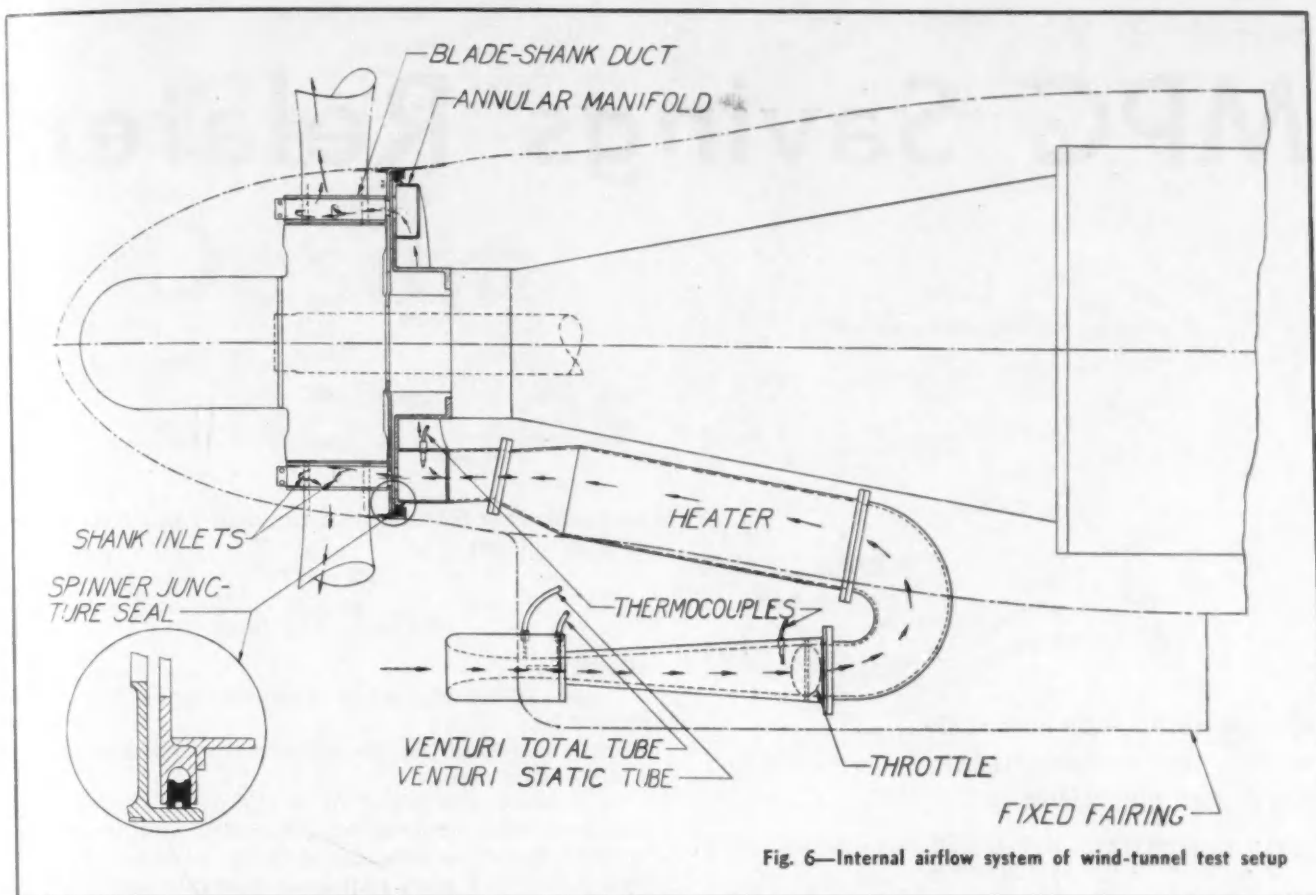
Fig. 6—Internal airflow system of wind-tunnel test setup

and that the internal flow system should be made as clean aerodynamically as possible to preserve propeller efficiency.

Still other series of tests were run with a complete heated-air anti-icing setup to determine the effect of heating the flow. Fig. 6 shows the principal components of the test setup. The apparatus was arranged to measure only the aerodynamic effects of the heated-air system on propeller efficiency. Tip openings were much smaller than those used for the earlier idealized investigation.

Again the propeller was first tested without tip openings. Then the openings were made and the tests repeated with internal airflow, but no heating. Finally tests with heated airflow were run. For those, air temperature was 285 F at the heater exit and 250 F at the propeller blade shanks.

Fig. 7 shows the results of the tests. Efficiency level for the normal propeller, which differed from the one used for the idealized tests, exceeded 90% over most of its operating range and reached a maximum of 92%. Operation with internal airflow —either heated or not—reduced efficiency only about 1% over most of the operating range.

Fig. 7—Effect of internal flow on envelope efficiency
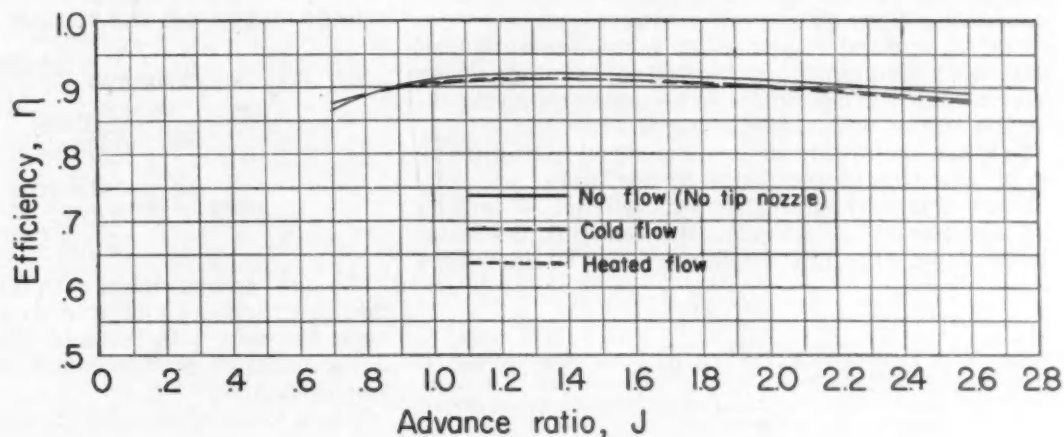
MPG Savings Related
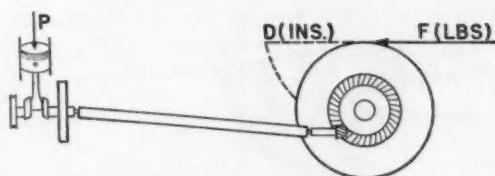
WORK (IN.–LBS.) = P(LBS./IN.²) x V(IN.³)

WORK (IN.–LBS.) = D(INS.) x F(LBS.)

F x D = P x V   OR   F = V/D x P

TOTAL THRUST (LBS.) = F = 1/2 x $\frac{DISP}{INCH}$ x IMEP

$\frac{DISP.}{INCH}$ = SWEPT CYL. VOLUME PER INCH

OF CAR TRAVEL.

Fig. 1—How engine work is related to car travel

(This paper will be printed in full in SAE Quarterly Transactions)

GAINS from the several ways of increasing car miles per gallon can be evaluated comparatively. Potential fuel saving yielded by each design change (overdrive, decreased wind resistance, reduced car weight, increased compression ratio, supercharger, and ideal automatic transmission) is judged by determining the resistance to be overcome in rotating the engine and in propelling the car.

To make such comparisons, a method first must be set up to estimate work done by the fuel.

Fig. 1 diagrams an engine and vehicle. A certain gas pressure in the cylinder, P in psi, will push the piston down through a volume V in cu in. This moves the car forward a distance of 1 in with a force of F lb. Then:

$$PV = FD$$

$$F = \frac{1}{2} \frac{\text{Disp.}}{\text{in.}} \times \text{imep} \qquad (1)$$

where:

Disp. = Displacement or swept volume of the cylinder, cu in.

imep = average gas pressure in the cylinder during the working stroke

As average gas pressure in the cylinder produces the force both for rotating the engine and propelling the car, it can be considered to be made up of these two parts: (1) part required to rotate the engine, called friction mean effective pressure—fmep, and (2) portion to propel the car, called vehicle mean effective pressure—vmep.

Since the force due to cylinder is as expressed in equation (1), then:

$$\text{vmep} = \frac{\text{Vehicle Resistance}}{\frac{1}{2} \frac{\text{Disp.}}{\text{in.}}} \qquad (2)$$

Under acceleration conditions, the force required to accelerate the vehicle at wide-open throttle is the difference between the total pressure in the cylinder (imep) and the sum of pressures required to rotate the engine and propel the car. Expression for miles per gallon is obtained by dividing the number of foot pounds of work possible to obtain from a gallon of gasoline (85,900,000 ft lb × thermal efficiency/100) by the number of foot pounds required to rotate the engine and propel the vehicle one mile.

$$\text{mpg} = \frac{85,900,000 \times \dfrac{\text{thermal efficiency}}{100}}{5280 \times \frac{1}{2} \dfrac{\text{Disp.}}{\text{mile}} \, (\text{fmep} + \text{vmep})}$$

$$\text{mpg} = 325 \times \frac{\text{thermal efficiency}}{\dfrac{\text{Disp.}}{\text{mile}} \, (\text{fmep} - \text{vmep})} \qquad (3)$$

To get comparative estimates of the effect of design changes on mpg, characteristics of a reference car were selected and effect of the particular design change on the reference car's performance was estimated.

When effect of changes in vehicle weight on engine

to Car Design Changes

EXCERPTS FROM PAPER* BY **W. S. James**

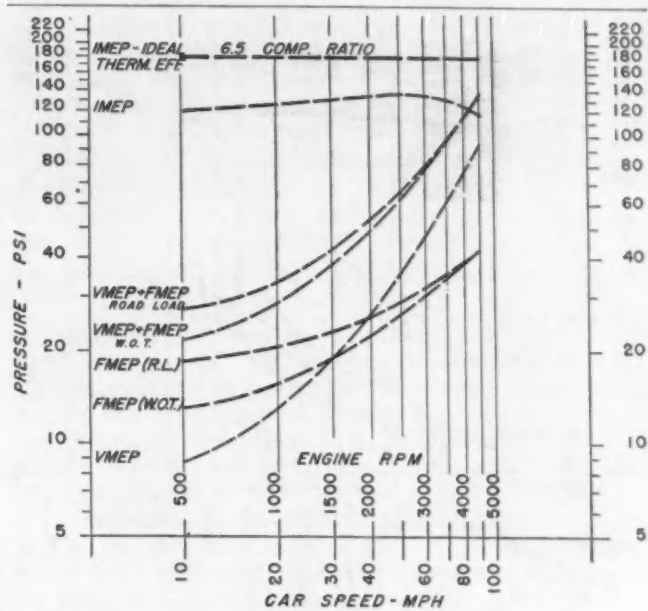Vice-President in Charge of Engineering
FRAM CORP.

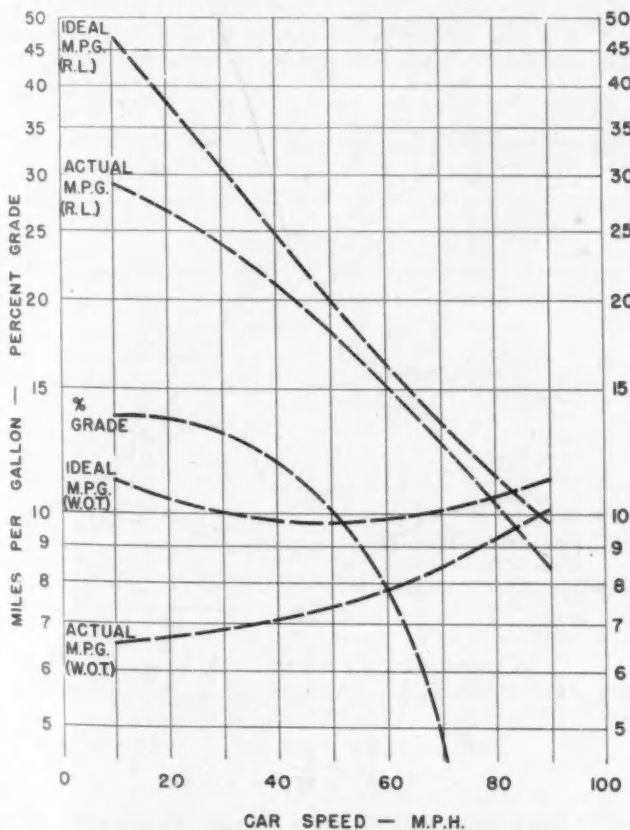Fig. 3—Performance of the reference car

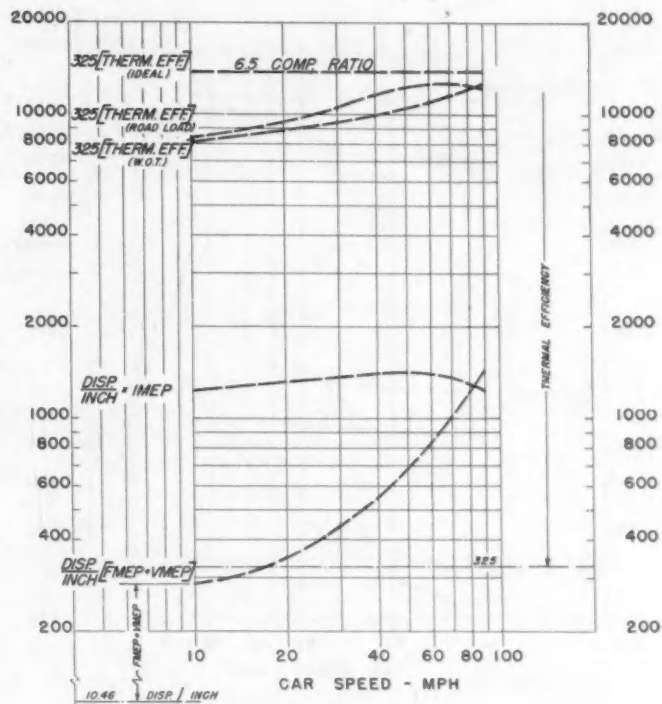Fig. 2—Hill ability and miles per gallon of the reference car

Fig. 4—Graphical computation of miles per gallon for the reference car

output were evaluated, corresponding changes in axle ratio and engine size were made to give the same accelerating and hill-climbing ability. Performance was readjusted to a preselected standard because, as is well recognized, the public will not accept a reduction in car ability.

Essential characteristics of the reference car are given in Table 1 and its performance—hill ability and mpg—in Fig. 2. Fig. 3 gives engine characteristics (imep, road-load fmep and full-throttle fmep as well as vmep). These data are not from any existing car, but rather representative of typical cars. The logarithmic plotting used permits much of the computation to be done graphically and equal distances represent equal percentage changes. Relative gains or losses can be easily evaluated.

In Fig. 3 the second curve from the top represents engine imep. Maximum possible imep with 100% volumetric efficiency, at 100 F and 29 in. hg, is shown on the top line. Vertical distance between these two curves is proportional to the percentage loss in volumetric and combustion efficiency.

The fmep at both wide-open throttle and road load are shown in the second and third curves from the bottom. Cylinder pressure to overcome vmep is given in the bottom curve. Also shown are fmep plus vmep.

Hill ability or available high gear acceleration will be proportional to the numerical difference between the imep and the sum of vmep plus fmep (at wide-open throttle). From these differences were obtained the negotiable grades in Fig. 2. Intersection of the imep curve and the curve for sum of vmep and fmep, in Fig. 3, indicates top car speed. The bottom horizontal scale gives the relation between car speed and engine speed.
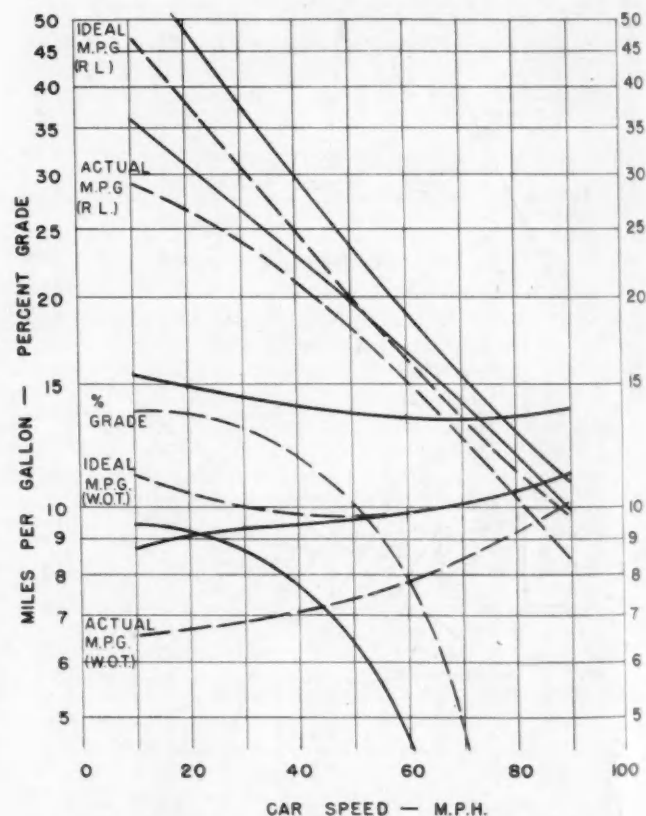

Fig. 5—Performance of the reference car with a 0.72 to 1 overdrive
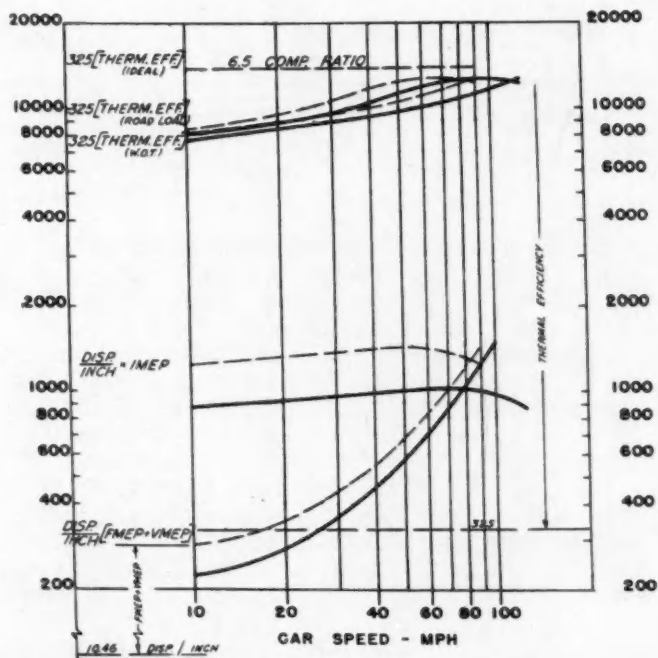
Fig. 6—Graphical computation of miles per gallon with the overdrive

Fig. 7—Comparison of both hill ability and miles per gallon with and without the overdrive

Economics of Gasoline Mileage

Fact that cost of gasoline is about one-third the cost of motoring points up the importance of increasing the miles per gallon of cars. With 38 billion gal of gasoline consumed annually in this country, even slight improvements in fuel economy can yield sizable dollar savings to the motoring public, the author says.

For example, a 1% gain in miles per gallon in every car would accrue a $90 million saving, or yield a mileage increase of 5¾ billion car miles. With these figures as a base, import of the following estimated losses are easy to visualize: Synthetic tires decrease miles per gallon by 5 to 6%, and neglecting to maintain proper tire pressures costs car owners 2 to 3% in miles per gallon.

If engineers could boost fuel economy of cars 5% through fuel-saving design features, they would save motorists a total of $450 million, assuming gasoline costs 24¢ per gal. But additional cost of the fuel-economizing device or method to the car owner must not exceed the fuel saving realized.

Ideal and presently possible mpg, as obtained from the expression in equation (3), are graphically solved in Fig. 4. This chart relates graphically the several factors involved so that effect of changes can be grasped quickly.

Here is how Fig. 4 was plotted:

The line for the constant 325 was located at the proper point. Using it as a base, required points for thermal efficiency were plotted. Since ideal thermal efficiency is independent of speed, it is represented by a horizontal line 42.2 above the 325 line on a logarithmic scale. (Theoretical thermal efficiency of this engine is 42.2%.) Thus points are located to represent the product of 325 and the thermal efficiency under consideration when read on the scale at left of Fig. 4.

Values of disp./in. (10.46) times the imep and disp./in. times the sum of road-load fmep plus vmep are plotted on the same scale as the 325. The verti-

cal distance between corresponding points on the imep curve and the wide-open throttle thermal efficiency curve, when read on a logarithmic scale, will be the mpg because the distance between these two values will represent the result of dividing 325 times thermal efficiency by the factor disp./in. × (fmep + vmep).

Values obtained from this manipulation are shown in Fig. 2. Vertical scale of Fig. 2, showing percent grade and mpg, is logarithmic to make easy comparisons of changes on a percentage basis.

With a basis for comparison established, it is now possible to give several examples of the method of estimating the effect of design changes on mpg.

Overdrive Gain Evaluated

Let us examine the effect of a 0.72 to 1 overdrive. All points on the imep and fmep curves, in Fig. 5,

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Table 1—Characteristics of the Reference Car

Weight
Shipping	3150
Road Equipment	150
Passengers & Baggage	400

Total 3700 lb weight = 115 lb mass

Vehicle Resistance
Frontal area	28 sq ft
Wind Resistance Coefficient	0.00178
Rolling Resistance	9.5 lb per 1000 lb weight
Total Resistance (lb)	$0.00178 \times 28V^2 + 0.6V + 35 = 0.05V^2 + 0.6V + 35$

Axle Ratio 4.06

Tire Size 6.00×16
Rolling Radius	13.6
Wheel Revolutions per Mile	740

Engine Rpm @ 10 mph 500

Engine
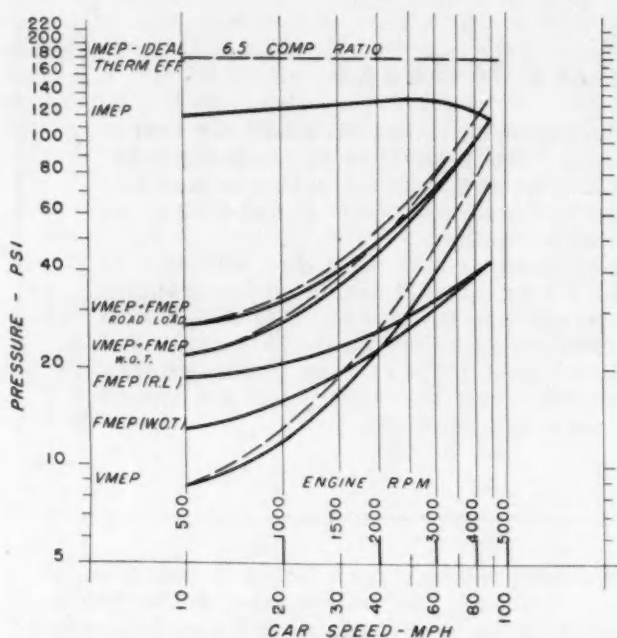|	
Displacement	220 cu in.
Compression Ratio	6.5
Displacement per inch of Vehicle Travel	10.46

Fig. 8—Effect of lowering the reference car's wind resistance by reducing both frontal area and wind-resistance coefficient
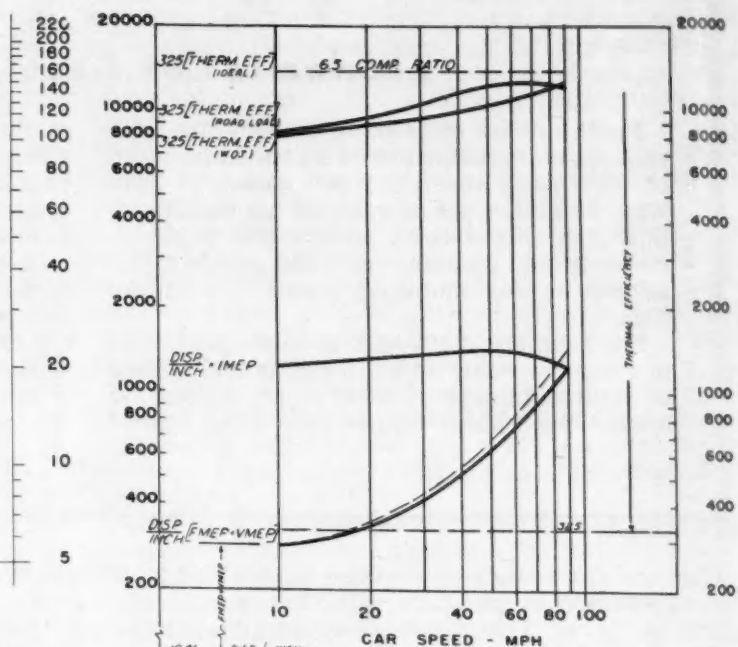

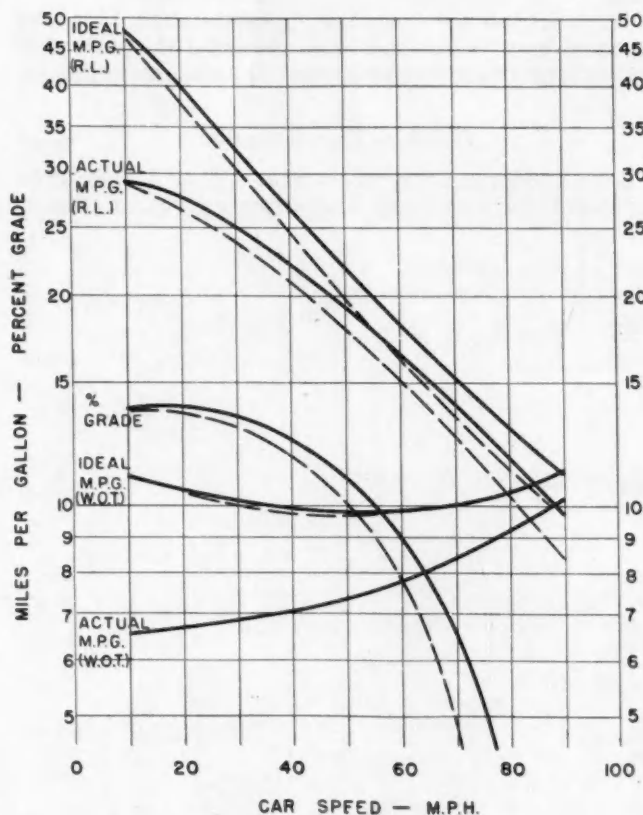Fig. 9—Graphical computation of mpg resulting from lowered wind resistance

Fig. 10—Gains in hill ability and miles per gallon from lowering wind resistance of the reference car

will move a distance of 1/0.72 or 1.39 logarithmic units (39%) to the right and all points on the vmep curve will move upward 1.39 units. The imep points move because engine speed for a given car speed is reduced 39%. The vmep points move upward 39% because engine displacement per inch of car movement has been decreased 39%, so that correspondingly more cylinder pressure is required to propel the car.

Light dotted curves show the original values for the reference car; heavier solid lines, those of the same car with the design modification (addition of an overdrive unit).

Decrease in the difference between imep and the sum of vmep plus fmep (road load) reduces hill ability and acceleration when in overdrive gear. Fig. 7 shows this loss in hill ability. Fig. 6 shows graphical computations for effect of lower engine speed on mpg. Here it is shown that although the value for the sum of fmep plus vmep has increased, the gain is less than the decrease in disp./in. Therefore road-load economy increases, as shown in Fig. 7.

If the overdrive ratio is cut out when the throttle is fully opened, as is usually the case, there will be no change in full-throttle mpg. Although effect of a 0.72 overdrive ratio on mpg at full throttle is not shown, it amounts to about 35% increase in the ideal and a 30% increase in the present mpg.

Effect of an overdrive on mpg is the reverse of that using second and low gear. In second gear, there is an increase in displacement per inch rather than a decrease, and the two lower curves in Fig. 6 would be above those of the reference car rather than below, as with overdrive. The vertical distance of these curves below those for thermal efficiency would be
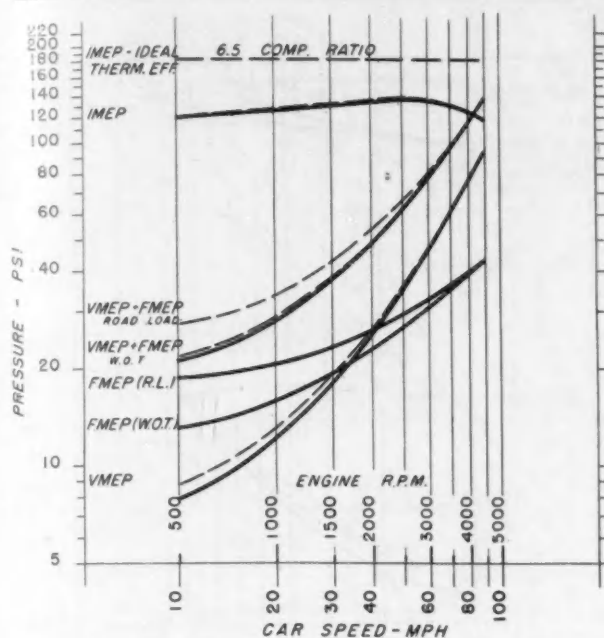
Fig. 11—Effect of reducing car weight 15% to permit use of a smaller engine
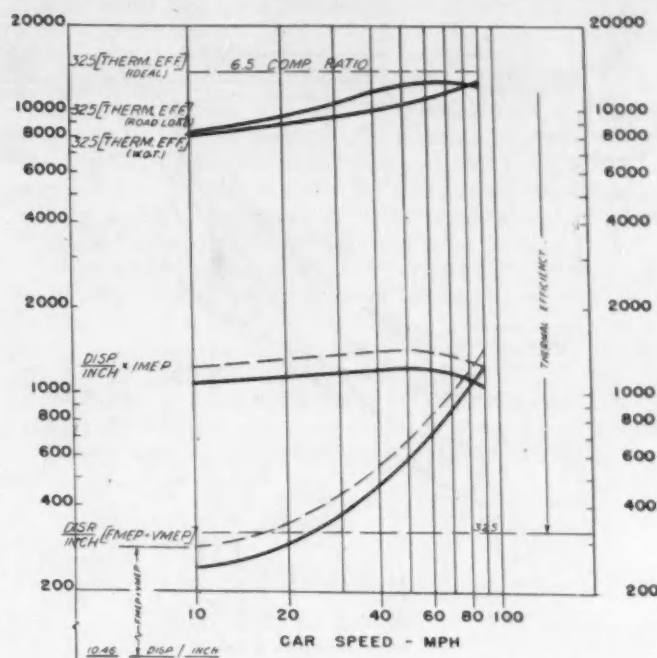

Fig. 12—Graphical computation of miles per gallon resulting from a smaller engine and 15% car weight reduction

decreased and mpg reduced by somewhat more than 50%, if the second gear ratio were about 1.5 to 1.

Savings by Lowering Wind Resistance

Curves on reduced wind resistance, Figs. 8, 9, and 10, are self evident. A 25% reduction in the product of frontal area and wind-resistance coefficient was assumed. This is possible if the frontal area is reduced from 28 to 25 sq ft, and the wind coefficient from 0.00178 to 0.0015. In this case, Fig. 8, there is no change in imep or in engine friction (fmep) at either road load or full load, but only a reduction in mep required to propel the car (vmep).

This change is reflected in the reduction of the product disp./in. times the sum of vmep plus fmep, Fig. 9, and a corresponding increase in the vertical distance between this curve and those for thermal efficiency shown at the top of Fig. 9. This vertical distance is the graphical solution of the algebraic equation (3) for miles per gallon.

Estimated results of this design change are given in Fig. 10. There is a gain in both hill ability and miles per gallon, which increases from nothing at low speeds to about 15% at the higher speeds.

Cutting Car Weight

When a smaller engine is used to compensate for a decrease in car weight to maintain the same hill ability and acceleration, the miles per gallon are increased, as shown in Fig. 13. Because there is a change only in engine size and none in axle ratio, there is no change in imep and fmep. But vmep decreases because of a reduction in rolling resistance —the result of lowering total weight—as shown in Fig. 11.
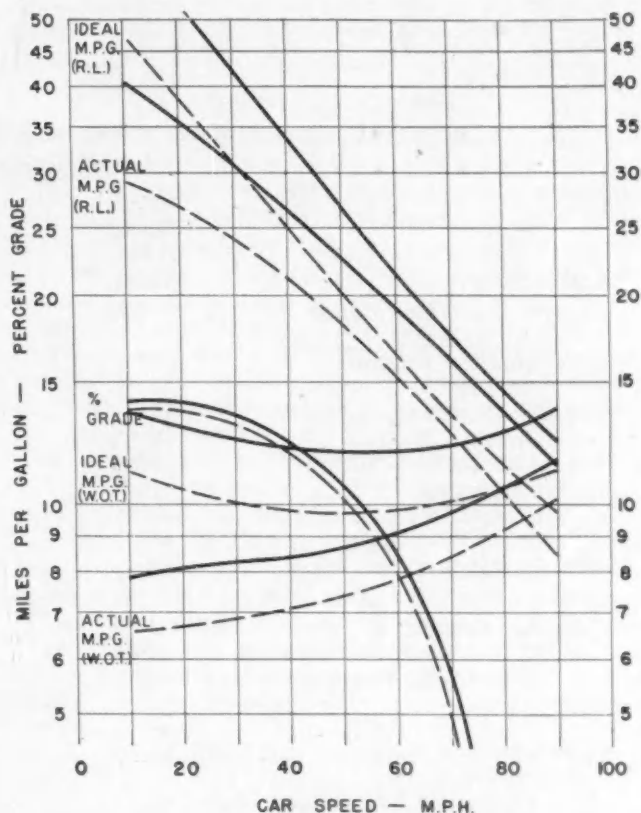
Fig. 13—The 15% car weight reduction yields the miles per gallon and hill ability shown
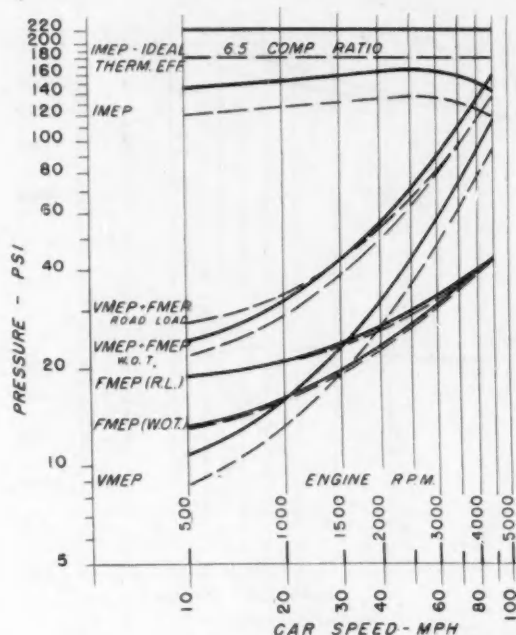
Fig. 14—Effect of boosting compression from 6.5 to 12 to 1 which permits reduction in engine size
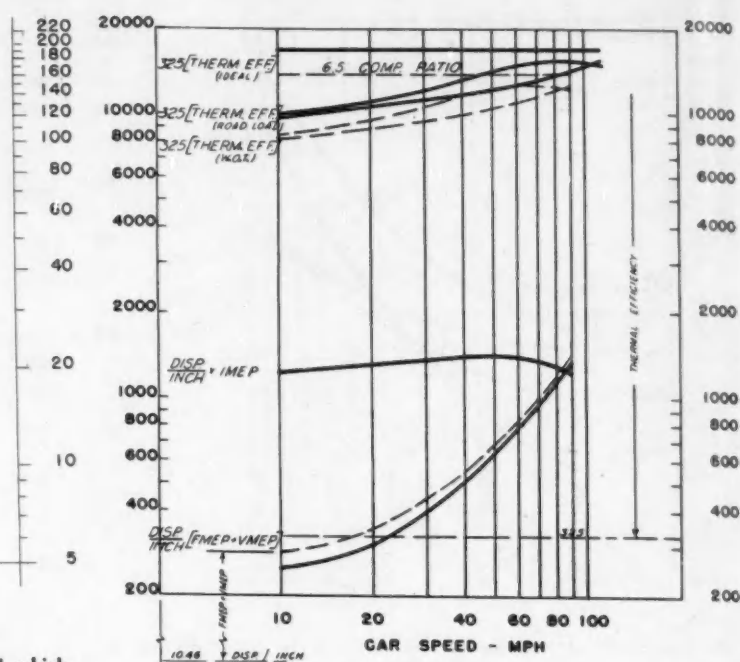

Fig. 15—Graphical computation of miles per gallon resulting from the compression ratio change

Table 2—Summary of Estimates of Increased Miles per Gallon by Various Means

Design Modifications

	Ideal Road Load	Maximum Wide-Open Throttle	Present Road Load	Possible Wide-Open Throttle
Overdrive	+20%	+37–0%	+13%	+26–0%
Lower Wind Resistance	+ 9%	0%	+ 8%	0%
Weight Reduction (15%)				
Smaller Engine	+17%	+15%	+16%	+16%
Axle Ratio Change	+12%	+13%	+10%	+12%
12 to 1 Compression Ratio				
Smaller Engine	+33%	+22%	+30%	+17%
Axle Ratio Change	+40%	+24%	+36%	+18%
Supercharging				
Smaller Engine	+17%	0%	+17%	0%
Axle Ratio Change	+24%	− 5%	+17%	−12%
Automatic Transmission	+48%	0%	+37%	0%

Estimated

	Ideal Road Load	Maximum Wide-Open Throttle	Present Road Load	Possible Wide-Open Throttle
Smaller Engine				
10 to 1 Compression Ratio	+25%	+16%	+22%	+12%
8 to 1 Compression Ratio	+12%	+ 8%	+11%	+ 6%

Other Means

Item	Range	Approximate Average
Reduction of Heat Loss and Incomplete Combustion	10 to 40%	15%
More Accurate Carburetor Metering	5 to 10%	15%
Fewer Traffic Stops	10 to 25%	20%

Fig. 16—Hill ability and miles per gallon of the smaller engine with the 12 to 1 compression ratio

imep) does not change because engine size (disp./in.) was decreased 23% when the higher compression ratio boosted imep 23%.

Effect of other design changes on mpg were estimated in a similar manner. Results of these design changes as well as several other items affecting mpg are given in Table 2. This table shows that there is more than one method for increasing miles per gallon by significant amounts. Selection of any one of these or other methods will depend on many factors . . . specific car or engine under consideration, manufacturing costs, tooling charges, operational simplicity, and fuel availability.

Automotive engineers are familiar with all these paths to greater miles per gallon. When overall compromises indicate desirability of their use, these methods will be adopted and the American public will get more and more miles for its motoring dollar.

Car Body Interiors

Cont. from p. 39

Already some progress has been made in this direction. One new car has individual front seats with backs folding horizontal to provide emergency beds.

A next logical step will be to try to pivot the right front seat out of the way entirely so as to provide easier access to the rear of the 2-door sedan.

Door Problem Complex

. . . And that brings us to doors—one of our most important and most complex problems in interiors.

Our problem on doors is to design our 4-door sedans for easy access within the standard 8-ft garage, while retaining the price advantage of the 2-door. . . . It's quite a problem. . . . I'm only posing it; not offering a solution.

We have experimented with the principle of sliding doors, but there isn't sufficient room to accommodate them. The folding door idea and various other improvisations are a wide open challenge to the designer.

Where we will be five or ten years from now I do not presume to know. Up to this time we have worked mostly on exteriors. I feel that that job is largely done. We have achieved the low silhouette and we have wiped off exterior gadgets and angles so that we have streamlining—the swift passage of the eye from front to rear—without embellishment.

The interior is the new challenge. We now have room to move around, to do things, free of the fixed limits which exterior design previously imposed. How well we do our job will be determined by how successful we are in carrying the atmosphere of the living room . . . its informality and flexibility . . . into the car interior. For the American family ranks its car just after the home in relative importance, and if we follow the accepted precedent of the one, we are sure to be right on the other.

Reduction in displacement per inch of car travel moves the two lower curves in Fig. 12 down, which increases the vertical distance between them and the upper curves for thermal efficiency. This indicates an increase in mpg, as shown in Fig.13. According to Figs. 11 and 12, obviously the major part of the mpg gain is due to the reduction in engine displacement per inch rather than the reduction in rolling resistance.

Estimate of the result of making the next design change—increasing compression ratio from 6.5 to 12 to 1—is shown in Fig. 16 and the graphical computation given in Figs. 14 and 15.

In Fig. 14, imep was increased about 23% from the higher compression ratio and fmep, at both road load and full load, increased about 2%. The vmep was increased 23% because this was the reduction in engine size necessary to give no change in acceleration. Therefore, a corresponding increase in cylinder pressure was necesary to give about the same hill ability and level-road acceleration. Fig. 15 shows the graphical solution of mpg.

The 23% increase in thermal efficiency due to the higher compression ratio is shown at the top of the chart. Reduction in the product of disp./in. and (fmep + vmep) gives the increase in mpg shown in Fig. 16. Wide-open throttle thrust force (disp./in. ×

CALENDAR

British Columbia Group—March 3 and April 7

March 3—Hotel Georgia, Vancouver; dinner 6:30 p.m. 32 Alundum—A new Concept in the Field of Abrasives—C. W. Fell, sales manager, Norton Co. of Canada, Ltd., Hamilton.

April 7—Hotel Georgia, Vancouver; dinner 6:30 p.m. Application of Dynamometer—E. L. Cline, manager, Dynamometer Division, Clayton Mfg. Co., El Monte, Calif.

Canadian—April 1

Hotel Royal York—Roof Garden, Toronto; dinner 7:00 p.m. My Friend the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., South Bend, Ind., and president, SAE.

Central Illinois—March 28

Hotel Jefferson, Peoria, Ill.; dinner 6:30 p.m. Relation Between Laboratory and Service Failures—R. E. Peterson. Chairman: Mark Clements, service manager, Caterpillar Tractor Co.

Chicago—March 8 and March 21

March 8—Hotel Knickerbocker; dinner 6:45 p.m. Meeting 8:00 p.m. Economics of Decentralized versus Centralized Truck Operations — Joseph Husson, automotive manager, Consumers Co., Chicago, Ill. Social Half-hour 6:15 to 6:45 p.m. sponsored by International Harvester Co.

South Bend Division—March 21

Hotel LaSalle, South Bend, Ind.; dinner 6:45 p.m. Meeting 8:00 p.m. Symposium on Laboratory Control of Pro-duction Materials at Studebaker—Speakers: William J. Harris, chief metallurgist, Studebaker Corp. (leader of panel); H. A. McChesney, assistant chief metallurgist; J. A. Baumgardner, lubrication engineer and R. D. Wysong, plant chemist.

Cincinnati—March 28

Hamilton, Ohio; visit plant of the Fisher Body Division of General Motors Plant. (Visit limited to 100 members who must complete tour between 6:00 and 8:00 p.m.) Dinner following tour 8:30 p.m.

Detroit—March 28

Large Auditorium, Rackham Educational Memorial Building. Dinner meeting. Dinner speakers: Students from Schools in Detroit Section Area. Technical Session: Stimulating Original Thinking in Young Engineers—Frank C. Mock, Bendix Products Division, Bendix Aviation Corp. Interesting movie to be shown.

Kansas City—March 8

Location to be announced; dinner 6:30 p.m. Performance of Today's Automobile Fuels and Lubricants—H. R. Kemmenov, Shell Oil Co., Wood River, Ill.

Metropolitan—March 10 and March 17

March 10—McGraw-Hill Auditorium, 330 W. 42nd St. Meeting 7:45 p.m. Joint meeting with Institute of Aeronautical Sciences and Met Section, SAE. Cockpit Standardization—Com.

NATIONAL MEETINGS ● 1949

MEETING	DATE	HOTEL
PASSENGER CAR, BODY, and PRODUCTION	March 8-10	Book-Cadillac, Detroit
TRANSPORTATION	March 28-30	Statler, Cleveland
AERONAUTIC and AIR TRANSPORT and AIRCRAFT Engineering Display	April 11-14	New Yorker, New York
SUMMER	June 5-10	French Lick Springs, French Lick, Ind.
WEST COAST	Aug. 15-17	Multnomah, Portland, Oreg.
TRACTOR	Sept. 13-15	Schroeder, Milwaukee, Wis.
AERONAUTIC and AIRCRAFT Engineering Display	Oct. 5-8	Biltmore, Los Angeles
DIESEL ENGINE	Nov. 1-2	Chase, St. Louis, Mo.
FUELS & LUBRICANTS	Nov. 3-4	Chase, St. Louis, Mo.
	● 1950	
ANNUAL MEETING and Engineering Display	Jan. 9-13	Book-Cadillac, Detroit

How Lightning Damages Planes

Based on paper by

M. M. NEWMAN

Lightning & Transients
Research Institute

LIGHTNING can damage parts of the airplane despite the inherently safe path for lightning currents around occupants and interior equipment formed by the aircraft's metal surface.

A recent direct record of a lightning stroke, recording its multiple discharge character, is presented by a pitted and burned propeller, shown in A. This propeller intercepted the lightning discharge channel within the cloud. The airplane was an all-metal twin-engine transport traveling at a normal cruising speed of 190 mph at 11,000 ft.

The photograph was retouched for clarity to show the pit marks and the probable discharge path. The lightning channel was drawn in a probable position at the completion of the discharge process. The channel is drawn out circumferentially by the last receding propeller-blade contact point.

In another case, the airplane was struck with one end of the discharge channel contacting a tail rudder bar. The ionized channel tended to remain in line as the airplane moved, so that repeated strokes hit the same place on the rudder bar. As B shows, the rudder strut was almost burned in half. Heat from the discharge contact on one side of the strut was enough to melt the opposite side and collapse it inward.

In the case illustrated in C, the antenna change-over relay contacts inside the transmitter unit were burned away by lightning current that entered along the antenna lead.

Surge voltage punctured the antenna insulator in D when lightning struck the antenna. Lightning current followed the antenna lead inside the airplane and flashed to ground inside the transmitter antenna change-over relay. In this case communications failed; in other cases, where the grounding path was completed outside the equipment, the radio equipment was set afire.

Other hazards to the aircraft from lightning are: (1) freezing of hinges in the ailerons if improperly bonded; (2) burning of holes in seaplane floats; (3) explosion of trailing antenna assemblies inside the ship; (4) induced voltage causing failure of electrical equipment; (5) effect of fused skin in the case of integral wing tanks; and (6) possible explosion from internal sparkover on wiring, igniting gasoline mixture. (Paper "Lightning Effects on Aircraft," was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 14, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Cutting Vapor Lock In Small Airplanes

Based on paper by

R. A. COIT
L. M. WHITNEY
F. G. BOLLO
and A. G. CATTANEO

Shell Development Co.

FROM a vapor lock standpoint, the gravity feed system of light aircraft can be much improved in two ways. But nothing short of redesign or pressurizing can make the diaphragm fuel pump vapor-lock-proof.

Two ways of bettering the gravity feed system are: (1) reducing the 25 to 35F fuel temperature rise between the tank and fuel line near the engine, and (2) keeping the pressure drop from
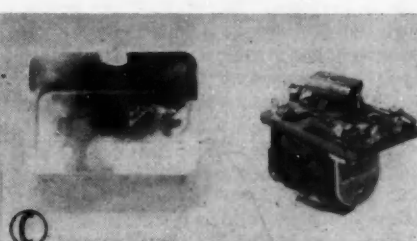

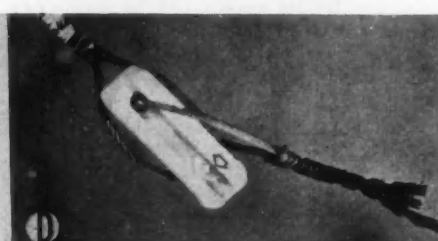A. Propeller pitted and burned by lightning
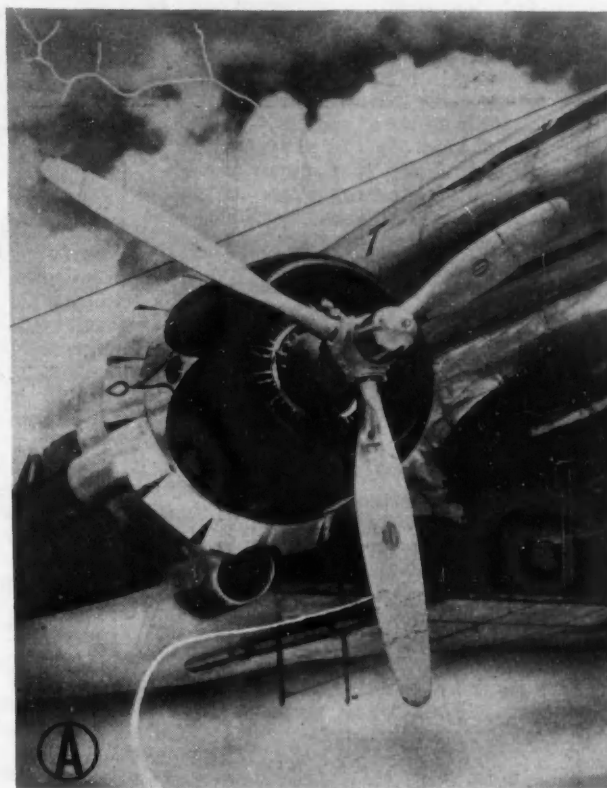
B. Lightning-burned rudder strut
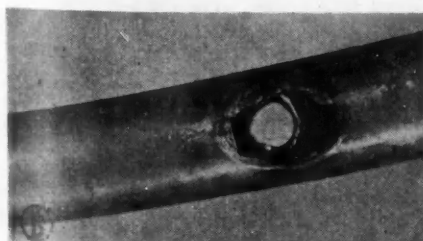
C. Lightning-damaged transmitter

D. Antenna insulator punctured by surge voltage due to lightning

tank to carburetor bowl as low as possible.

This means that the fuel line must be kept as far as possible from heat sources and should be shielded from direct radiation from the exhaust pipe. Cooling air heated by the engine should be deflected away from the fuel system and a direct blast of unheated air substituted. The fuel system should be as short as practicable, have no high spots where vapor may be trapped, and have large enough radii of curvature.

In a properly designed and installed system of this kind, no vapor lock will occur with aviation gasoline under any condition. But automotive gasoline would be unsafe in such a system under any but the milder temperature and altitude conditions.

Fuel System Pressurized

The problem can be solved in military aircraft where even a 7-psi Rvp fuel would vapor lock under the much more extreme conditions of larger fuel-system pressure drop and greater altitude and temperature extremes. It can be done by using centrifugal pumps submerged in the fuel tank, which keep the fuel system under a pressure 10 to 15 psi higher than the atmosphere.

By virtue of their design, these pumps centrifuge out the vapors and discharge only liquid fuel. They present no cooling problem since they operate in the coolest part of the system.

A similar pump recently has been introduced for automotive applications. In a pressurized system of this type even automotive fuels could be used in light aircraft without danger of vapor lock under any operating conditions. But since diaphragm-type fuel pumps are coming into use for light aircraft, their vapor-lock performance is of interest. This fuel pump vapor locks at a temperature considerably lower than the fuel line or carburetor bowl. For this reason it is the most critical part of the system.

With a fuel temperature rise of 20F, the pump may vapor lock at sea level for any ground temperature above 105F on 7-psi Rvp aviation fuel. Reducing the fuel temperature rise to 10F would boost the altitude limit to 2000 ft under the same condition.

New Design Possibilities

It seems likely that with the new multivalve heads and other pump improvements the vapor-locking limits of the diaphragm-type pump could be extended—possibly enough to match the performance of the fuel line and carburetor bowl.

Merely enlarging the pump or increasing the vapor-handling capacity in other ways will help a little; but these cannot be considered final solutions since the vapor volume, once the fuel starts to boil, increases two to five

times within a further temperature rise of only 5F. (Paper "Light Aircraft Vapor Lock Problems," was presented at SAE Northern California Section, San Francisco, June 23, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

CAA Engine OK Speeded By Follow-Up from Start

Based on paper by

GAYLORD W. NEWTON
Boeing Airplane Co.

CAA certification of aircraft engine installations can be made a less involved procedure by proper presentation of the design in its initial stages. Particular emphasis should be given items getting most attention from CAA personnel due to service and accident experience.

CAA Liaison Urged

Modern aircraft powerplants are sufficiently complicated so that over a year is required for their design and construction, and another year for testing and approval. To reduce possibility of certification delays, an early presentation should be made to Civil Aeronautics Administration engineers assigned to the project.

It is very effective to discuss early layouts and to make use of mock-ups of critical parts and of the entire installation. Such an educational program gives the government a background to permit early approvals of portions of the installation.

Early Planning

One thing hard to get is definite assurance of approval of important design decisions. Often a basic parameter, such as firewall design, will depend on CAA decision. It's important to get a firm approval; change at a later date may upset the airplane's building schedule.

A powerplant lends itself to breakdown into systems and specific problems for presentation. A letter, drawings, and diagrams can be submitted to CAA for approval. This material should contain all the pertinent facts so that a decision can be made. By this means it is possible to review most controversial items in time to make design changes where necessary.

Here are some things to keep in

mind on specific items of the powerplant installation:

1. Engines—Early analysis of the aircraft design needs permits selection of proper conditions under which the engine type test will be run. In this way the final CAA type inspection authorization can contain the required values. Another important point is to make sure the engine is equipped with as many final accessories as possible during its type test.

2. Propellers—The aircraft builder should be assured of complete coordination between propeller and engine manufacturers. Vibration tests and limitations are paramount.

3. Fuel System—Principal problem with fuel system certification is determination of unusable fuel. Recent accidents point up fuel vent installations. Using the color fluid discharge from the vent demonstrates whether the discharge constitutes a hazard.

4. Oil System—One of the biggest obstacles in getting oil system approval is properly fireproofing the oil shutoff valve and its control if located forward of the fire wall. It calls for extensive testing of the complete oil tank and valve setup; usually electrical parts and seals as well as heat transfer characteristics of the assembly are involved.

5. Exhaust System—Care must be taken that shrouds are tight enough to conduct possible leakage of inflammable fluids away from the exhaust. In some cases it has been done with seamless shrouds, continuous weld joints on shrouds, and double shrouds.

6. Cowling—Fire tests have shown pockets in the cowling that are undrained create a serious hazard. Adequate drain holes should be provided early in the design.

7. Fire Prevention—Basic fire extinguishing systems are well outlined in requirements and interpretations. But zones in which they are installed are subject to special interpretations. Also the next year or two will see considerable testing and coordination with CAA to get satisfactory criteria for approval of fire and smoke detectors.

8. Flight Tests—An outline of proposed flight tests should be forwarded to CAA as soon as the manufacturer formulates his flight testing plans. Most important powerplant flight test for certification is the cooling test. Cowl flap angles to be used during performance demonstrations must be carefully determined during engine cooling tests. (Paper "Powerplant Problems of CAA Certification," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 9, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Man as a Machine

Excerpts from a talk by **F. G. SHOEMAKER**
Detroit Diesel Engine Division
General Motors Corp.

AS engineers we all have a fairly accurate knowledge of the numerical value of the various units of work, energy, heat, and force. Personally, I am almost perfect in this respect since all the important units and their values are shown in neat tables on the back of my slide rule. But I always have had difficulty in getting a satisfactory physical concept of these units.

How big is an erg? What sort of a stream is a flow of 10 amp? How many Btu's in a tea kettle? And entropy! Whenever I see the word entropy I think of what happens when a snake swallows its own tail. A mathematician evidently got to wondering about that too and added another snake loop through the first one and called the result enthalpy.

I'm confused.

Let's consider horsepower.

It has been stated that a good healthy man has an 8-hr rating of about ¼ hp. This is equivalent to carrying 396 bags of cement up a 100-ft hill in 8 hr, or a 6-v battery discharging at a rate of 32 amp, or a 200-watt lamp, or the total heat of 1/3 pint of fuel oil.

Recently I bought a small garden tractor. The fuel tank holds about 1 qt. In previous years I hoed the garden by hand and it took all the energy I had left each evening and week end to wage a losing hand-to-hand battle with the weeds.

That 1 qt of gasoline in the 150 lb of iron in the tractor is a better man than I ever hoped to be. I have doubled the size of the garden. I can now afford a bench at one end of the garden. And I have time to sit and enjoy the clean, orderly rows. If doing nothing is a measuring stick, then I have improved my standard of living.

One gallon of fuel oil used in a diesel engine equals eight men working for 8 hr, or about 2¢ per man per day for fuel. Liquid hydrocarbons are the most concentrated form of power now available. It is particularly fortunate for the transportation industry that two-thirds of the fuel, oxygen, already is distributed free in the air to every point on the earth.

In contrast, the fuel for man runs as high as $1 per lb for solid fuel and $6 per 4/5 qt for liquid fuel. As an engine, man weighs about 700 lb per hp. It is easy to see that manpower is highly expensive.

Despite the high cost of manpower, it does not follow that man is an unimportant part of the transportation machine. On the contrary, he is unquestionably a most perfect machine, as indicated by his general specifications.

1. Complete, self-contained, completely enclosed powerplant.
2. Available in a variety of sizes.
3. Reproducible in quantity.
4. Long life.
5. Life-time guarantee.
6. All major components in duplicate.
7. Weatherproof.
8. Amphibious.
9. Runs a wide range of solid or liquid carbohydrate fuels.
10. Thermostatically - controlled temperature.
11. Circulating fluid heat.
12. Evaporative cooling.
13. Sealed lubricated bearings.
14. Audio and optical direction and range finder.
15. Sound and sight recording.
16. Audio and visual communication.
17. Equipped with brain controls.

It is this last item—brain control—that makes man a unique machine and is his most important function in power transportation.

Application of this brain power by engineers in the transportation industry makes it possible to coordinate movement of the fuel, powerplant, and vehicle together with the payload. When the vehicle can carry more payload than that required to cover total operating cost of the complete vehicle, the fleet operator realizes a profit. Common objective of the transportation business and its allied industries is more payload. (Dinner talk "More Power to You," was presented at SAE National West Coast Meeting, San Francisco, Aug. 20, 1948.)

Airline Troubles Laid To Revenue Disparity

Based on paper by

W. L. McMILLEN*

American Airlines, Inc.

DIAGNOSIS of the airlines' economic ills reveals that the real cure lies on the income side rather than the cost phase of operations. Airlines operate in a competitive atmosphere, yet regulation deprives them of normal competitive weapons.

Despite severe inflation during the postwar period, airline costs have held their own and even moved downward. Cost per available ton-mile flown by American Airlines for the 12 months preceding July 1, 1946 was 33.7¢; for the 12 months preceding July 1, 1948, 30.9¢; and it was less than 26¢ in July, 1948.

The increase in fares has decreased the breakeven passenger load factor even more. For the 12 months preceding July 1, 1946, the figure was 82.7%; for the one-year period prior to July 1, 1948, it was 71.5%, and for July, 1948, between 56 and 57%.

Real progress has been, and is being, made on the cost side by other airlines too. Let us look on the revenue side of the picture. Here we find the Civil Aeronautics Board has permitted and encouraged too much competition. Revenue is divided into such small slices among so many that there is not enough for any one airline to meet even lower cost units.

A company accepting a certificate under the public utility concept of a regulated industry gives up many privileges, which are important in controlling its destiny and insuring profits. But in return it is supposed to get freedom from excessive competition. The airlines have paid the price, but haven't received the benefits.

For example, route duplication upon route duplication has been authorized. Three or four airlines are flying daily between cities where traffic can support only two, if they use larger and more economical equipment. Use of obsolete equipment boosts costs so that profits are wiped out, even with a good load factor. But not one of them can maintain a good load factor on an annual basis.

Competition among certificated carriers is only part of the story. Many hundreds of nonscheduled competitors have purchased war surplus airplanes at bargain-basement prices. Many have kept their books on a cash rather than accrual basis and have little idea of their costs. Most have failed. The several passenger carriers, illegally operating on a scheduled basis, cut into

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the limited revenue pot and further reduce that available for regular airlines.

First step on the road back is to stop certificating more airlines. Airline mergers that cut the number of carriers between cities where there are now too many should be permitted and even encouraged. Rate and fare structures should be revised to make each type of traffic bear its fair share of the cost.

Palliatives of high subsidy, increased fares, and government loans should be used only where financial soundness of the carrier is attainable in months, not years. (Paper "Some Economic Problems of the Air Transport Industry," was presented at the SAE National Aeronautics Meeting, Los Angeles, Oct. 7, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

Lack Yardsticks for Phenomena To Explain Diesel Combustion

Based on paper by

J. J. BROEZE
and C. STILLEBROER

Delft Laboratory,
Royal Dutch Shell

FORECASTING diesel fuel behavior is an impossibility without knowing a great deal more than we do about the actual mechanism of mixture formation in the particular engine under test. But as yet, our knowledge of complex diesel combustion problems are largely qualitative rather than quantitative.

On the fuel side we know that if more heat units have been introduced during the delay period, due to higher volumetric heat content or less pump leakage, chances are that ensuing knock will be heavier. But viscosity, connected with volatility, also affects spray formation and dispersion.

For example, we have experienced various cases where a more volatile fuel (despite its lower viscosity and specific gravity giving lower injection rate in heat units per degree), would knock worse for a given delay because of its more completely vaporized state at ignition start. Yet we have found cases where a more volatile fuel knocked less—probably because this more volatile fuel evaporated so quickly

that vapors concentrated locally and formed an over-rich mixture.

Certainly it is impossible to rate fuels according to the way they behave in the second combustion phase since their behavior in different engines may conflict.

Factors exerting predominant influence in later combustion phases are air movement, spray formation and dispersion, fuel volatility, and wall temperature. Since these phases cannot be discerned as such on the indicator card, we must turn to combustion as a whole. What interests us here are products of complete combustion and combustion efficiency.

Briefly and simplified, this is the situation:

Under-penetration causing local over-richness tends to produce soot. Over-penetration, wetting relatively cold walls, forms aldehydes and blue vapors. More generally, soot stems from lack of air; aldehydes, from chilled combustion.

Conducive to under-penetration from the fuel side are high volatility (low viscosity) and high cetane number. The reverse properties are conducive to over-penetration. Yet over and under-penetration are closely connected with design as well as load, speed, and temperature. Since the entire preparation and combustion proc-

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Curves "a" through "g" are for engines under constant conditions of slight overload; curves "h" through "l," for constant fast idling. A and B are direct-injection engines; C and D, precombustion-chamber engines; E, F, and G, swirl-chamber engines. Boundaries of regions of nearly constant smoke density coincide, as a rule, with the curves of constant fuel consumption; otherwise, they have been separated by dotted curves. Twenty different fuels were used in these tests.
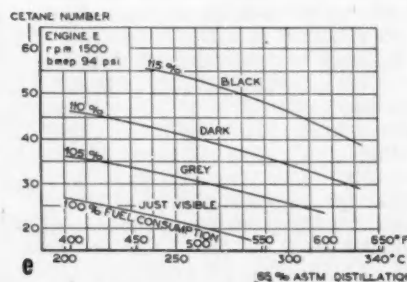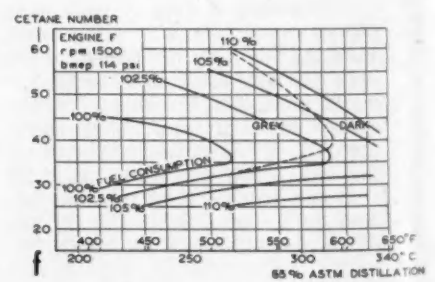
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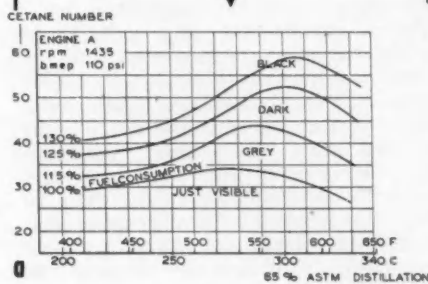
Fig. 1—Curves of constant fuel consumption (by weight) and
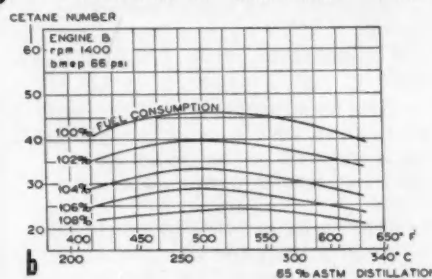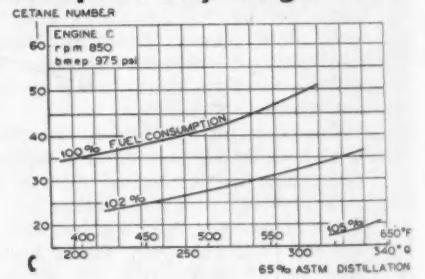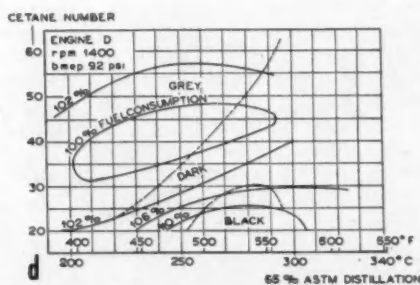
ess is extremely heterogeneous, both faults may even occur together. In such a case, if it is not due to overload and the injector is working properly, design is obviously bad.

Complicated nature of these combined effects is shown by graphs we plotted (Fig. 1) from fuel consumption and smoke observations, on several high-speed diesel engines running on widely different fuels. Observations were made under fast-idling conditions and under slight overload. Of course under intermediate loads the results are more equalized and differences hardly show up. Data have been plotted as lines of constant fuel consumption on bases of volatility (which correlates sufficiently well with viscosity for this purpose) and cetane number.

While explanation of these 12 charts is too detailed, some important features do stand out. For example, under fast-idling conditions, the general tendency for fuels of high octane number is to show an advantage as to consumption. Smoke is more dependent on volatility. There is a certain correlation between this blue smoke—sometimes thickening into grayish white—and aldehyde smell.

It is clear that under overload conditions there is no correlation between different engines. Each produces a rather distinct pattern, showing that for each engine one certain set of fuel properties produces optimum conditions. But optimum fuel properties are all over the map if different engines are compared.

Choosing the most suitable fuel for an engine demands consideration of starting, knock, and idling; this calls for a compromise on power performance. Here again if we knew quantitatively more about combustion, we would not build an engine that needs some certain fuel for an acceptable compromise and is penalized performancewise.

Apparently the diesel engine, unlike the gasoline powerplant, does not depend on a definite fuel property for its performance. In fact it would be quite feasible to develop a combustion system for any fuel in particular, giving peak power production on that particular fuel. Variations in performance obtained in such way on fuels that differ within reasonable limits would amount to a few percent. But even on a given engine, without making any adjustment, difference remains within about 10%.

At peak power most of the air will be burned. Much greater gain in power can be realized by supplying more air to the engine than by choice of fuel—with no limit set on the fuel, provided combustion chamber conditions are readjusted.

The sometimes disappointing results of supercharging diesel engines also may be read off some of the charts in Fig. 1.

Performance drop for an increase in cetane number may point to under-penetration—at least in direct-injection engines. In such a case supercharging would aggravate the condition and we would not get a rise in

power proportional to the air supply increase.

In some cases the disappointment was traced to an overloaded injection system, producing after-injections at high fuel loads. But generally engine sensitivity to fuel properties will decrease with supercharging, which makes this way of increasing performance still more attractive.

More quantitative facts about diesel combustion will come by systematically trying out fuels of various cetane number and volatility on different engine types. After relating engine design, fuel properties, and resulting performance, next step would be to bring performance in line experimentally with knock, idling, acceleration, and starting requirements on the same fuel grade for all engines.

The search for an extra-performance fuel—equivalent to high-octane gasoline—is entirely out of place in the diesel engine field. The limit is set by quantity of air, not by any fuel property. Nor does a fuel property like "combustion quality" exist; results depend predominantly on design. For this reason ultimate choice of a universal fuel grade is relatively free from combustion and performance considerations. (Paper "Fuels for Automotive and Railroad Diesel Engines," was presented at the SAE National Tractor and Diesel Engine Meeting, Milwaukee, Sept. 7, 1948. This paper is available in full in multi-lithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

regions of nearly constant smoke density plotted against fuel volatility and ignition quality

g — ENGINE G, rpm 1500, bmep 105 psi

h — ENGINE A, rpm 1500, bmep 92 psi

i — ENGINE C, rpm 400, bmep 375 psi

j — ENGINE E, rpm 1500, bmep 215 psi

k — ENGINE F, rpm 1500, bmep 16 psi

l — ENGINE G, rpm 1500, bmep 18 psi
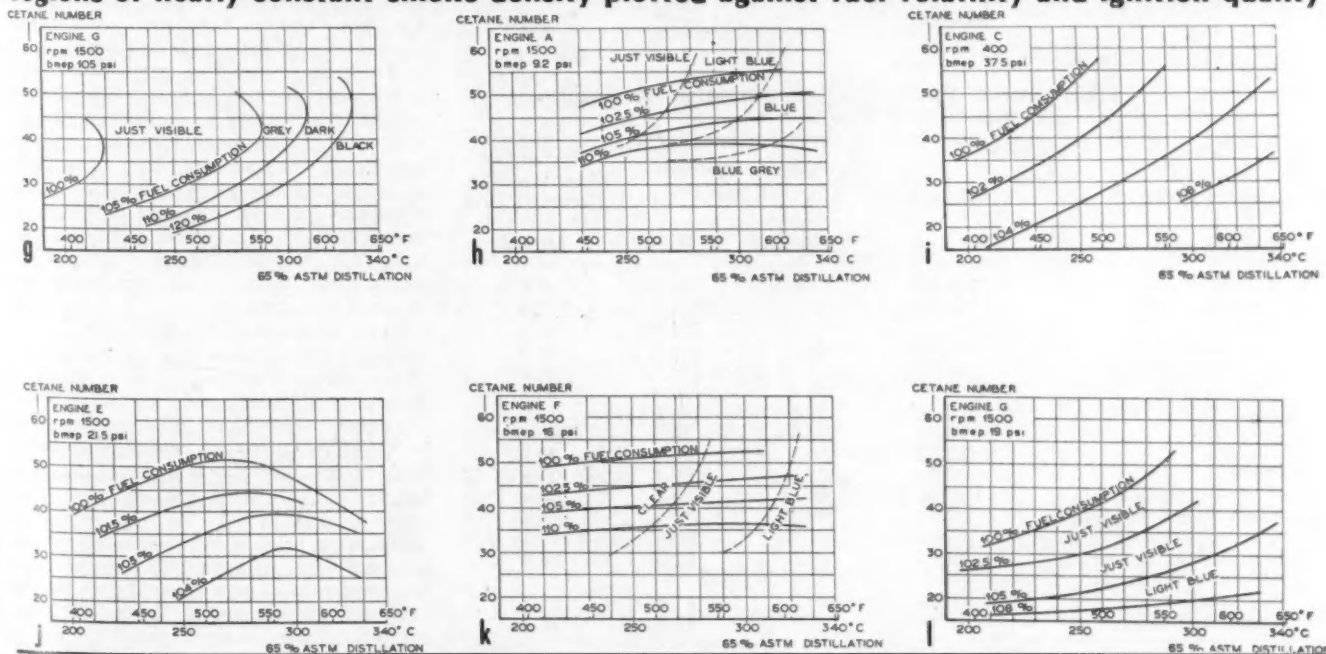
Examines Economics of Diesel Tractor

Excerpts from paper by

H. F. BRYAN

International Harvester Co.

EXTENT of diesel power's economic advantage over the gasoline engine for farm tractors depends largely on the price differential between the two fuels and the number of hours per year the farmer uses his tractor.

A natural advantage enjoyed by the diesel engine is that while the farmer purchases his fuel by the gallon, the engine consumes it by the pound. Since diesel fuels are about 12½% to 15% heavier than gasoline and contain more heat units per gallon, the purchaser of heavy fuel actually gets more power for his money. But a disadvantage of the diesel is its higher initial cost.

To compare the two, let us analyze costs with two tractors—one gasoline and the other diesel—each operating on a farm with 360 acres under cultivation. Each farm is laid out as follows: corn, 120 acres; soybeans, 40 acres; small grain, 100 acres; hay, 60 acres; and pasture, 40 acres.

Each tractor is assumed to be performing the same operations. Table 1 shows these operations, as well as the average hours required for each per year; percent of brake horsepower of the engine required to perform the operation; and the relationship between the amount of gasoline and diesel fuel consumed to perform the operations.

Total time required to perform all the specified operations is 972 hr. Average power demand is 50.4% of the engine's total brake horsepower.
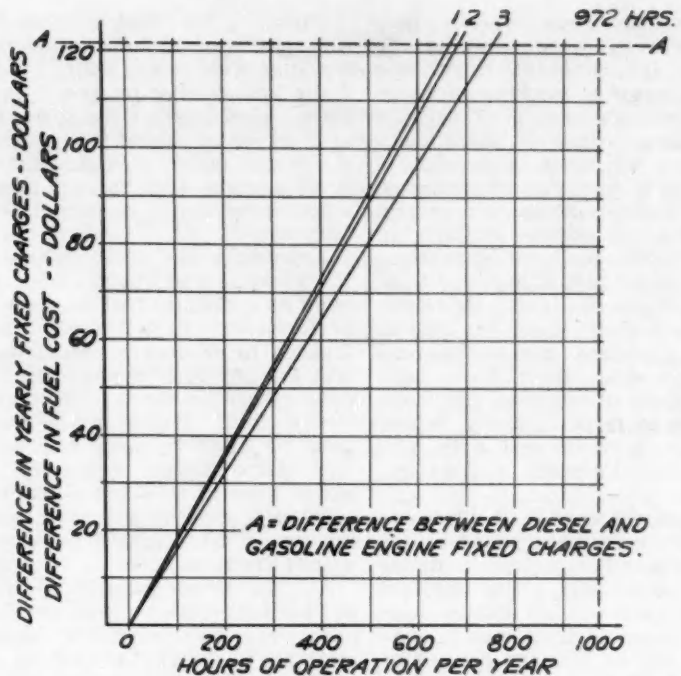
Fig. 1—Relationship between fixed charges and fuel cost of diesel and gasoline engines for tractor operation

Average yearly fuel consumption of the diesel engine is 73.1% that of the gasoline engine.

It is interesting to note the ratio of diesel to gasoline consumption shows a definite reduction on the lighter loads. This is characteristic of the diesel engine.

To determine the net difference in fuel costs between the two operations, the following tank wagon delivery prices for two fuels without tax have been applied. These prices were current in Iowa, Illinois, and Kansas in March, 1948.

● Gasoline—regular 70-74 octane. Price per gallon was: Iowa, 18.6¢; Illinois, 18.8¢; Kansas, 17.1¢.

● Diesel Fuel—house brand. Price per gallon was: Iowa, 13.0¢; Illinois, 13.3¢; Kansas, 11.8¢.

When these fuel prices are applied to the data in Table 1, it is found that the fuel cost of the diesel engine for the year's operations is only 53% of gasoline engine fuel cost. If reduction in fuel cost was the only consideration for farm tractor operation, the diesel engine would dominate the field.

But this is not the case—there is a debit side to the ledger. The diesel engine costs more to build because of high-priced component units and it also lacks the cost reduction advantage of large mass production. The fixed charges—such as depreciation, interest, insurance, and taxes—are higher for this reason. And because of costlier parts and accessories, maintenance charges are greater.

Price of the diesel-equipped Farmall is about $656 higher than the gasoline unit. Experience with these tractors indicates a life expectancy of at least 10 years. Therefore, with a complete write-off within this period, depreciation of the diesel-powered tractor will be $65.60 per year greater than the gasoline unit.

Because of the higher initial cost, interest on investment, taxes, and insurance is correspondingly higher and will approximate $35.68 per year more than the gasoline unit. Estimates

Table 1—Comparison of Yearly Fuel Consumption of Gasoline and Diesel Tractors

Operation	Hours	Percent of Brake Horsepower		Percent of Gasoline Fuel Consumption
		Gasoline	Diesel	Diesel
Plowing	228.50	75.0%	79.0%	75.6%
Discing	100.00	67.1	69.9	72.9
Planting	60.00	47.6	50.0	71.0
Harrowing	13.50	68.5	72.0	74.0
Rotary Hoe	45.50	31.1	32.7	67.50
Cultivating	180.00	37.6	39.9	68.60
Drill & Harrow	20.50	71.5	75.1	74.5
Mowing	16.75	26.8	28.3	66.6
Raking	16.75	26.8	28.3	66.6
Baling	26.00	26.0	27.4	65.3
Threshing Grain	50.50	43.6	30.9	66.4
Harvesting Ensilage	18.25	72.8	76.5	74.1
Corn Picking	45.50	67.2	70.7	73.7
Threshing Beans	20.25	43.6	31.0	66.6
Manure Spreader and Hauling	80.00	16.9	17.7	65.5
Feed Grinding	50.00	71.2	75.0	76.3

of the total repair and maintenance costs for the life period based on service records for 3500 to 5000 hr of operation show the yearly maintenance cost of the diesel unit may be slightly higher than the gasoline unit.

When all charges are added, it is found that the total yearly fixed charges for the diesel unit will be about $121.63 per year greater than the gasoline unit charges, based on the year's operation shown in Table 1. Average yearly fuel cost of the gasoline unit will be $365 and for the diesel, $193—a fuel cost saving of $172. This deducted from the fixed charges yields a net saving of $50.37.

It is evident from these data that higher initial cost with higher fixed charges will constitute a major handicap to the diesel engine unless low cost fuel is available, or the tractor is used a large number of hours per year.

Relationship between the estimated and fixed charges and cost of the two tractors is shown in Fig. 1.

Break-Even Point

In this chart line A-A intersects the left-hand vertical ordinate at the difference between the fixed charges of the two tractors. Curves 1, 2, and 3 are based on the hourly savings with the three fuel price combinations on an operation, as shown in Table 1. Slope of these curves shows the hourly rate of saving in fuel cost; they intersect line A-A at the number of hours per year the diesel engine must operate to absorb the difference in yearly fixed charges through savings in fuel costs.

In other words, the number of hours will show a net saving over the gasoline engine.

With the fuel price combination in Iowa and Illinois as shown, the diesel will yield a saving after 666 hr; but with the Kansas price combination, 730 hr of operation will be required. Obviously any reduction in the difference between the price of gasoline and diesel fuel will increase the number of hours of operation before the fixed-charge difference is absorbed.

Remember that these figures are based on performance of gasoline tractor engines, which give outstanding fuel economy. As engine size is increased, fuel consumption of the diesel engine becomes even more favorable and fixed charges relatively less.

Although the larger tractor presents a brighter picture for the diesel engine, many MD Farmalls in operation are saving money for their owners. (Paper "The Adaptability and Economics of the Diesel-Powered Farm Tractor for Small and Moderate Size Farms," was presented at the SAE Oklahoma A & M Student Branch, Stillwater, April 22, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

SAE National Transportation Meeting

Hotel Statler
Cleveland, Ohio

March 28-30

MONDAY, March 28

10:00 a.m.

O. W. SMITH, Chairman

Comparing Fundamentals of Spring Suspensions
—N. E. HENDRICKSON, Consulting Engineer, Laguna Beach, California
Assisted by MURRAY FAHNESTOCK, Ford Field Magazine
(Sponsored by Transportation and Maintenance Activity)

2:00 p.m.

M. B. RATH, Chairman

Recent Developments in the Magnetic Fluid Clutch
—JACOB RABINOW, National Bureau of Standards
The lecture will be illustrated with demonstrations both on the clutch and the fluid
(Sponsored by Truck and Bus Activity)

TUESDAY, March 29

9:30 a.m.

G. H. SCRAGG, Chairman

The World's Largest Field Dynamometer— Its Design and Instrumentation
Sixty-Ton Truck Design
—GEORGE BRUMBAUGH, Peterbilt Motors Co.
(formerly with Knuckey Truck Co. Inc.)

One-Thousand-Horsepower Electric Drive Equipment
—J. E. WILSON, General Electric Co.. Erie Works
Instrumentation of Field Dynamometer
—H. L. CLARK, General Engineering and Consulting Laboratory, General Electric Co.
(Sponsored by Truck and Bus Activity)

2:00 p.m.

W. G. PIWONKA, Chairman

Commercial Trailer Selection
—J. J. BLACK, Trailmobile Co.
(Sponsored by Transportation and Maintenance Activity)

WEDNESDAY, March 30

9:30 a.m.

P. B. ROCKWOOD, Chairman

Modern Engine Testing Equipment
—M. E. NUTTILA, Cities Service Oil Co.
(Sponsored by Transportation and Maintenance Activity)

2:00 p.m.

R. S. HUXTABLE, Chairman

Trend in Heavy-Duty Brake Developments
—C. S. RICKER, American Machinist
(Sponsored by Truck and Bus Activity)

DINNER

6:30 p.m. TUESDAY

Welcome—**Norman Hoertz,** Chairman, SAE Cleveland Section

Donald C. Hyde, Toastmaster   **S. W. Sparrow,** SAE President

The Berlin Air Lift

Rear Admiral John P. Whitney, Vice-Commander
Military Air Transport Service

Truck Design Sets Three-Point Goal

Based on paper by

E. S. ROSS

Peterbilt Motors Co.

AUTOMOTIVE engineers must design trucks satisfying needs of the fleet operator, mechanic, and driver.

For the fleet operator:

The truck must carry the maximum load within state laws.

For the mechanic:

Accessibility for maintenance is paramount.

For the driver:

Comfort must be provided.

Achieving the first objective together with good weight distribution in the face of widely-varying state requirements is a seemingly simple, but actually tough, problem.

First it must be realized that the tractor will be allowed to carry only that portion of the gross load which its wheelbase length will allow. On this point state laws vary; some use a formula for the gross weight of a unit. This formula—L plus 40 times a constant—is based on the wheelbase L feet long plus a constant 40 times another constant. This second constant varies from state to state, ranging from 670 in West Virginia to 800 in Arizona. Other states have a table of weights which is based on a similar formula.

In addition to satisfying legal requirements, the design must make maintenance easy. If the mechanic must spend long hours changing a fuel pump or transmission, both operator and mechanic won't like it. Revenue-producing time is wasted in repair and the job taxes the mechanic's patience.

Designers constantly must be on their toes to provide easy maintenance. He can use such things as quick disconnector blocks between the chassis wiring harness and cab harness to facilitate removal of the cab. The way he positions lube oil and fuel filters and fastens the floor boards also can increase accessibility for maintenance.

Third goal for the truck engineer to shoot for is driver comfort. A driver not aggravated by tantalizing little things will get the truck over the road, take care of equipment, and be satisfied with his job.

Emphasis must be placed on the size of cab, visibility, ventilation and heating, ease of steering, and seat size, shape and action. All go into making up driver comfort and satisfaction. (Paper "Problems of the Automotive Engineer," was presented at the Fresno Division of the SAE Northern California Section, Sept. 13, 1948. This paper is available in full in multi-lithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)
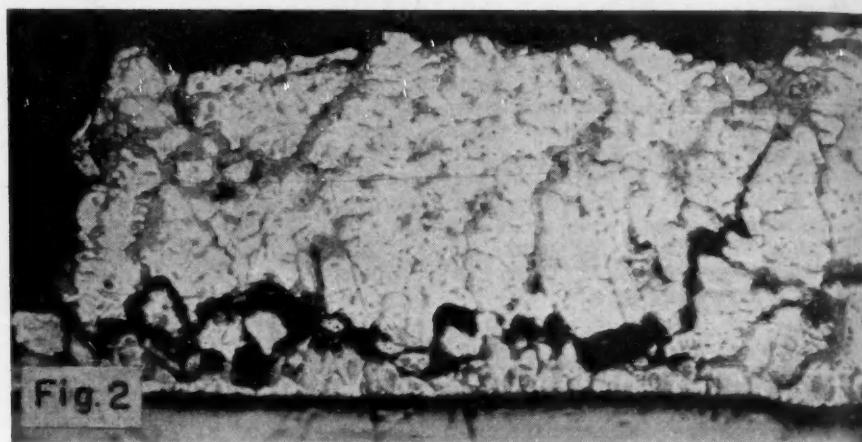
FIGS. 1 to 4—Though both look alike, the copper-lead bearing failure in Fig. 1 was caused by fatigue, the one in Fig. 3 by corrosion. Micro-examination of these bearings (by cutting out the sections outlined in white) shows up the differences. Micrograph of the fatigue failure in Fig. 2, enlarging the section 150 times, reveals that a crack has progressed along the light gray lead stringers parallel to the steel back. The lead is uncorroded even on the exposed bearing surface. Top shows bearing surface; center, cross-section; and bottom, junction of bearing metal to steel back. (Copper is white and the lead pearl gray.)

Micrograph of the corrosion failure, Fig. 4, shows the gray lead has been removed quite uniformly from the upper third of the bearing thickness, leaving a partially broken mass of compacted copper crystals. Presence of gray lead all the way out to the bearing surface, as in Fig. 2, is always positive evidence that no corrosion has occurred—provided the cross-section covers a complete transverse bearing section through the area of greatest load.

How to Diagnose

Based on paper by

J. M. STOKELY

California Research Corp.

(This paper will be printed in full in SAE Quarterly Transactions)

OBJECTIVE analysis rather than preconceived notions will disclose quickly causes of bearing failures in the field.

This is the four-step procedure recommended for investigating bearing failures in the field:

1. Carefully examine bearings for signs of cracks after cleaning in gasoline or light solvent and flex gently. If cracks are present, solvent will be forced out of them and the cracks will be clearly outlined on the bearing surface. Presence of cracks indicates that failure is probably influenced considerably by fatigue.

2. Abrasion is evident from scratches or imbedded material. Pry out imbedded particles and test with a magnet. Magnetic particles are iron and steel; nonmagnetic ones may be dislodged bearing material, failed bronze gear parts, or filler material from a broken filter. Check the filter for unusual deposits or leakage of filter material.

3. Check all factors that might contribute to over-heating, mechanical, or corrosion failures.

4. Determine whether similar failures have occurred in this fleet or other similar ones. Check with local service representatives of the engines involved.

Failures of copper-lead bearings are the most troublesome to diagnose. The average observer finds difficulty in differentiating between corrosion and fatigue failures in these bearings.

For example, the typical copper-lead
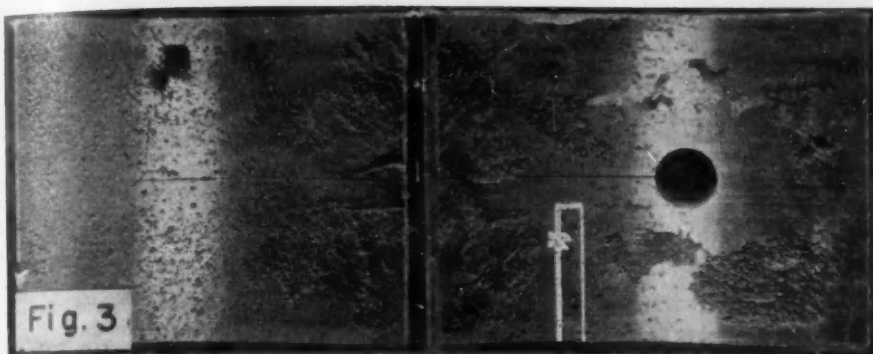
Fig. 3
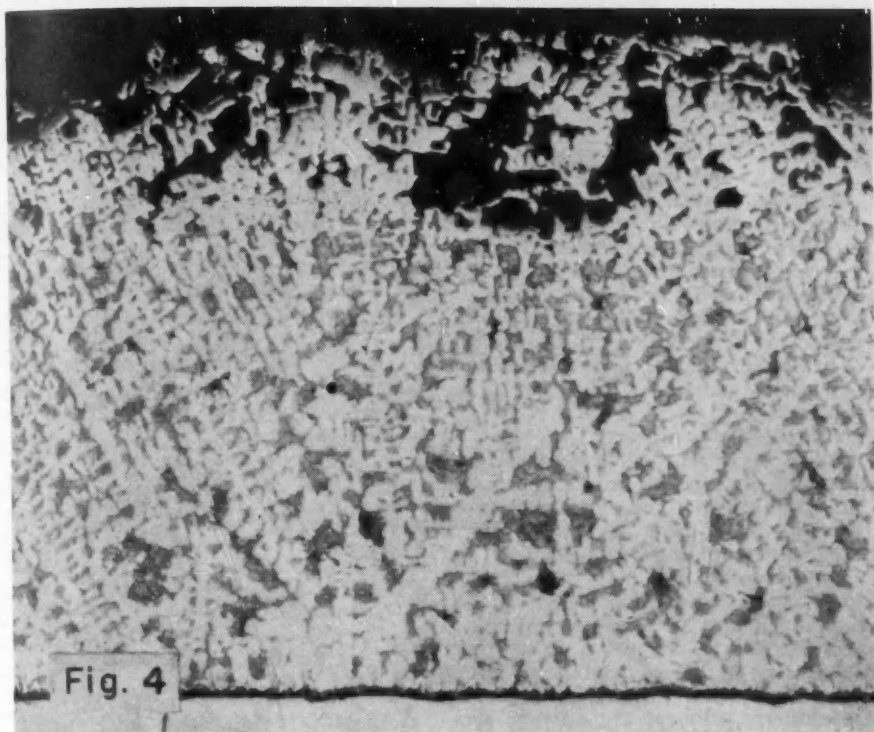
Fig. 4

Bearing Failures

fatigue failure in Fig. 1 looks a lot like the typical corrosion failure with such bearings, in Fig. 3. Micrographs in Figs. 2 and 4 of these bearings readily distinguish one from the other.

When a metallographic examination can be obtained, the entire bearing set should be submitted, even though only part of the bearings are damaged. Many decisions can be made from a complete bearing set that are not possible with only one or two of the worst bearings.

Reason for this is that corrosion generally affects all bearings, while fatigue or overheating may be limited to one or two. Submitting only a single bearing leaves the laboratory investigator guessing at the exact condition of the rest of the set.

By the same token it is important to submit an adequate sample of the used oil and a sample of the fresh oil. Many deductions can be made from

special analyses of these samples to aid in determining cause of failures.

Fleet men will save themselves trouble by remembering that the best time to prevent further bearing failures is in the field—as soon as failures are found. Ideal time to check all factors causing corrosion or fatigue failures is while the engine is still torn down. Correcting the cause at that time may prevent future failures.

Leaping to hasty conclusions that either the bearing metal or the oil is at fault obscures the real cause. Even with inferior oils, abnormal operating conditions contribute to failure. (Paper "Engine Bearing Failures," was presented at SAE National West Coast Meeting, San Francisco, Aug. 18, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

PB-10 Automatic Pilot Suited to Airline Needs

Excerpts from paper by

P. A. NOXON

Eclipse-Pioneer Division
Bendix Aviation Corp.

The PB-10 meets requirements of an autopilot for commercial aircraft—it's safe, provides adequate performance, is easy to maintain, adaptable to any commercial airplane, and flexible in design.

Take the first item, safety. Toward this end a series signal circuit is employed. In addition there is a grid biasing arrangement which, in effect, constantly checks the d-c continuity of the signal circuit by allowing a small amount of d-c to flow.

If an open appears anywhere in the circuit, the first two grids have a high negative bias applied to them, effectively preventing any signal from reaching the servo. The bias on the discriminator—mag amp stage is such that, at quiescence, little current flows in either mag amp control coil. This means that a mag amp open will produce a one-sided control, or at the most a weak adverse signal and not a hard over.

In addition, the heater circuits of the various tubes are so arranged that a burn out of one kills the whole channel.

The next point is performance. No adequate yardstick has been developed for this illusive matter. But it appears logical that for passenger comfort one should seek to limit the accelerations felt by the passenger as a result of gusts. If we consider the effect of a gust on an airplane to consist of a sine wave, or portion of a sine wave, it is obvious that for a given departure from datum the higher the frequency, the higher the acceleration felt by the passenger.

In the PB-10 we seek to confine the frequency band at which disturbances occur to that defined by the normal control constants of the automatic pilot-airplane loop; and it has been our observation by recording automatic flight that this is actually accomplished practically. While curves so obtained show a fortuitous mixture of waves of different amplitude and phase, as far as can be observed, the result of a single gust is a portion of a sine wave having a frequency in the predicted band at an amplitude depending upon energy in the gust. Such high frequencies as appear apparently occur in the structural region and are normally of extremely low amplitude. For good performance we do require a high sensitivity.

There is another aspect to performance which concerns both safety and comfort. That is the use of a rate signal in yaw. Practically all airplanes are under-damped in yaw; and most

modern airplanes, in addition, have relatively high rolling moments with yaw. These two factors produce a tendency to wallow. This the rate signal (which in effect greatly increases yaw damping of the airplane) inhibits; so normally there is no observable tendency for the airplane to wallow while on automatic control in rough air. This is greatly appreciated by the passengers in the rear seats.

Last item involved in performance is maneuverability. This feature the PB-10 provides by means of the controller through which a coordinated turn of the airplane can be effected by turning the pistol grip controller handle.

It is possible to make good coordinated turns over a wide range of airspeeds with a given adjustment. In addition, the airplane may be maneuvered in pitch and trimmed in bank by knobs provided for that purpose.

Simple Maintenance

Next requirement to be met is ease of maintenance. An important factor is the use of a simple circuit design, if possible—one that readily can be understood by the average radio technician.

The PB-10 servo amplifier channel is fairly straight forward. The only unusual element being perhaps the mag amp, which in itself is relatively simple. Circuit accessories not shown—such as, power supplies, bypass condensers, phasing resistors—are familiar to every radio service man. The flux gate compass amplifier is somewhat more complicated. But this element as part of the flux gate system has been on the market for several years and presents no maintenance hazards to airline personnel.

Use of the magnetic amplifier-induction motor servo drive avoids the use of commutators and brushes which have in the past been a source of some difficulty in aircraft electrical equipment. Trouble from this source is therefore avoided; the servo requires no maintenance except periodical inspection and relubrication.

To avoid as many places as possible to look for trouble, the PB-10 design collects as many things in one package as could be managed. Comprising this package are the amplifier signal generator unit, which contains the vertical rate gyros; the flux gate amplifier; the three servo amplifier channels; the ratio adjustment; the relays used for caging and interlock systems; necessary high transformers; and the altitude control. The remaining elements have either functional or installation reasons for being separate.

Fourth requirement is adaptability. It is our practice to match the servo to the airplane control surface by the choice of the proper pulley or sector size. We adjust the torque levels, if necessary, by resistors, which are placed in series with the motor windings. Four potentiometers are provided

on the amplifier signal channel unit. One of these is associated with each servo channel. Regulating the value of servo follow-up voltage, serves to fix the amount of servo travel obtained with a given signal to that required for the particular surface with which it is associated.

The fourth potentiometer enables one to select the amount of rate signal to be used in the rudder channel. An adjustment plate is provided, which is chained to the amplifier rack in which the amplifier unit is mounted. Since the amplifier will not operate without this plate in place, the adjustments, in effect, stay with the airplane and allow one to interchange signal generator and amplifier units freely.

These expedients have sufficed to permit the successful use of the PB-10 in every airplane so far attempted without any circuit or mechanical modification of any sort being necessary.

Last requirement to be met is that the system must be flexible. Use of an electrical system inherently provides a freedom for additions and modifications, difficult to approach by any other technique. The simple series input system of the PB-10 permits insertion of external signals in any desired channel, without disturbing the rest of the equipment or upsetting the adjustments of the amplifier.

Since terminals are already for this purpose, incorporation of the basic PB-10 into a more comprehensive system involving other parameters is a relatively simple matter. (Paper "The PB-10 Automatic Pilot for Air Transport," was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 15, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Enhanced Car Interior Demanded of Stylists

Based on paper by

HELENE ROTHER
Rother Design-Styling Studios

TROUBLE with car styling today is that it concentrates on outside appearance, neglects the inside. Stylists should become aware of customer desire in interior colors, fabrics, gadgets, and functional accommodations.

Continued use of drab gray and tan interiors controverts American love for color. Most women throughout the country quizzed on interior color desires like red; others responded, "deep green with very little silver."

Along with the use of more colors our whole conception of fabric textures also should change. Maybe the fabric women want is a miracle fabric because it is not here yet. But all they want is a fabric they can wash and clean.

And if you're going to sell the women, remember that advertising has made her gadget-conscious. They want everything from outlets for heating baby bottles and canned soup to umbrella holders and safety belts. This problem also involves engineers, to determine what a car battery can stand in gadgets.

Functionally interiors also can stand improvement. Ornate instrument boards and over-sized buttons and complicated ornaments that bruise knees and elbows are outdated.

And while the same car exterior can satisfy needs of different people, the same interior cannot. For example the farmer should have another interior than the urbanite using his car for home-to-office transportation. Traveling salesmen and others would appreciate something approaching the convenience of an office inside their cars. Families with lots of children require a different interior than a single man or woman.

Making interiors fit people's needs should be the first step toward improving them. (Paper "Are We Doing a Good Job in Our Car Interiors?" was presented at SAE Detroit Section Nov. 15, 1948.)

Analyze Dynamic Loads In Airplane Structure

Based on paper by

E. S. JENKINS
and C. D. P. PANCU
Consolidated Vultee Aircraft Corp.

(This paper will be printed in full in SAE Quarterly Transactions.)

CAREFUL dynamic load analysis will yield efficient use of structural weight. This is evident in larger, faster airplanes in both landing and flight, where transient vibrations produce important stresses.

If history of exciting forces is known, a dynamic analysis is feasible. Methods used require careful application to account for complex structural distortions successfully. Responses are calculated by a classical linearized solution. From these the loads are determined.

Examples of dynamic loads are the bending moments in an airplane hull

TECHNICAL COMMITTEE PROGRESS

Steel Physicals Related to As-Quenched Hardness

A NEWLY-PUBLISHED SAE report, Physical Properties Influenced by As-Quenched Hardness, goes a long way toward settling the controversy among metallurgists over the degree of sub-surface hardening needed to get adequate physical properties in a steel part. Prepared by a group of the SAE Iron & Steel Technical Committee, this report presents the first published data of this kind which show that full as-quenched hardness develops greater physical properties.

Metallurgists are divided into two schools of thought as to how far the quench should bite. One group believes that part must be hardened all the way through (getting complete transformation from austenite to martensite) to do the best possible job; the other feels lesser amounts of hardening are adequate.

Investigations reported in this new publication —based on tests with three different kinds of steels —tend to support the first group.

Table 1 gives analyses of these materials. Although only three steels were tested, they were selected with care to provide information applicable to other steels. Metallurgists consider them good choices.

Test results for these three steels show the ratio of yield strength to ultimate strength increases with an increase in as-quenched hardness. See Fig. 1. This was especially true of the 13T45 steel, which shows the greatest increase in ratio of yield to ultimate strength. Since design stress almost always is based on yield strength values, says the report, it seems especially desirable to get the full as-

Fig. 1—How as-quenched hardness affects tensile strength, reduction of area, and elongation of the steels tested. That full as-quenched hardness develops increased yield strength (shaded portion) is particularly significant since this is the value on which design stresses usually are based

the three grades at equal hardness.

Analysis of the photomicrographs seem to show that a duplex structure—composed of high and low transformation products—tend more toward brittle failure than a duplex structure of lower bainite and martensite, constituents formed at relatively low temperatures.

Another fact emerging from these investigations is that shot peening of partially hardened structures cannot be relied on to replace complete hardening to bolster resistance of steel.

The investigation on which this report is based was started in 1944 by the Hardenability Subcommittee of the SAE War Engineering Board, Iron & Steel Technical Committee. At that time automotive practice varied widely as to the as-quenched hardness needed to get optimum physical properties after tempering.

The SAE Performance Requirements Committee then was preparing a chart showing what steels and various size sections satisfying engineering needs for various degrees of physical properties. Without any data on minimum as-quenched hardness requirements, metallurgists would have had to rely on their own past experience. This project was undertaken to develop factual data on as-quenched hardness needs.

The Report on Physical Properties Influenced by As-Quenched Hardness (SP-53) is available from the SAE Publications Department. Price: $1.00 to SAE members, $2.00 to nonmembers.

Members of the Hardenability Subcommittee that developed the report are: A. L. Boegehold, Research Laboratories Division, GMC, chairman; W. H. Graves, Packard Motor Car Co.; E. O. Mann, Chevrolet Division, GMC; F. E. McCleary, Chrysler Corp.; R. W. Roush, Timkin-Detroit Axle Co.; R. B. Schenck, Buick Motor Division, GMC; E. H. Stilwill, Chrysler Corp.; F. C. Young, Ford Motor Co.; H. B. Knowlton, International Harvester Co.; and H. Bornstein, Deere & Co.

quenched hardness of which the steel being treated is capable.

There does not seem to be any significant difference in elongation or reduction of area with respect to a change in as-quenched hardness. But if any generalization were to be made, elongation and reduction of area tend toward slightly higher values as as-quenched hardness is increased.

Impact strength also increases as the quenched hardness is upped, according to the report. Impact strengths of the three steels at equal hardness values differ considerably. Difference in microstructure of the as-quenched blanks may partially explain this behavior. Photomicrographs (of which there are 22 in the report) picture this difference in structures of

SAE Lighting Standards Expanded and Modified

THREE new lighting specifications and modifications of four existing ones, developed by the SAE Lighting Committee, recently received Technical Board approval.

The new lighting specifications are:

1. SAE Recommended Practice for School Bus Warning Signals. This covers electric warning signal systems identifying the vehicle as a school bus and informing other vehicles on the highway that the bus is about to stop, or is stopped to take on or discharge school children. The signal system defined in this specification calls for al-

Table 1—Analyses of Three Steels Tested

Steel	Heat No.	C	Mn	P	S	Si	Cr	Ni	Mo	Addition agent
1345	126405	.43	1.58	.020	.019	.31	.05	.01	.01	None
13T45	126405	.43	1.59	.018	.016	.45	.05	.01	.01	Silcaz #3*
4140	128456	.41	.88	.023	.032	.27	.88	.08	.15	None

* Silcaz No. 3 added at the rate of 3 lbs. per ton, analysis was:

B	Si	Al	Ti	Zr	Ca
.44	39.54	6.60	9.84	7.49	9.68

ternately flashing lights (each lamp flashing from 60 to 120 times per min), two mounted on the rear and two on the front of the vehicle. Photometric tests are specified and installation recommendations made.

2. SAE Standard for Motorcycle and Motor-driven Cycle Headlamps. Specified here are photometric values selected to give seeing distances called for in the Uniform Code. A motor-driven cycle is defined by Act V of the Uniform Code as every motorcycle, including every scooter with a motor which produces not more than 5 hp and every bicycle with a motor attached.

3. SAE Recommended Practice for Liquid-Burning Emergency Flares. This specification covers weatherproof and reliability and life tests for these warning devices. The weather tests are designed to simulate wind and rain conditions. Total burning time specified, including 15 min in an air stream of 40 mph, is 12 hr.

The four specifications modified are:

1. SAE Recommended Practice for Direction Signal Lamps. This specification now covers two classes of signal lamps instead of one for type 1 units (units which provide their indication by a combination of flashing light and position on the vehicle). Photometric tests under this type are spelled out for Class A signal lamps (for vehicles 80 in. and wider) and for Class B lamps (for vehicles less than 80 in. wide).

2. SAE Recommended Practice for Electric Emergency Lanterns. Modifications to this specification permit the use of the gaseous discharge tube type (neon light), which emits a flashing signal, as well as the incandescent type. Both types are for use with flammables where a pot torch would be hazardous.

3. SAE Standard for Stop Lamps. Revision in this case involves eliminating the requirement on minimum projected luminated area, leaving only the candlepower requirement. This change was made because these lamps no longer carry the word "stop."

4. SAE Recommended Practice for Back-Up Lamps. The Photometric test distance in this specification has been reduced from 60 to 15 ft to facilitate laboratory testing.

Another item approved by the SAE Technical Board, publication of general information on the industry test specification for Sealed Beam headlighting units in the 1949 SAE Handbook, will make this material generally available for the first time. This test specification is used by the automobile industry for spot checking Sealed Beam units in production.

A new project being undertaken by the SAE Lighting Committee is the supervision of comparative tests of

Technishorts . . . .

RUBBER SPECS: The numbering system for SAE rubber standards will be revised in the 1949 Handbook. Designations are being changed for coolant hoses, fuel and oil hoses, brake hoses, windshield wiper hose, natural rubber cups, and hydraulic brake fluid.

SPARK ARRESTERS: The SAE Spark and Flame Arrester Subcommittee is working out a tentative standard for testing devices to prevent fires caused by engine exhaust flame and incandescent particles. The test procedure being developed involves the introduction of a given amount of battery carbon into the engine. Effectiveness of the arrester will be judged by the amount and size of carbon particles escaping the arrester.

H-BAND STEELS: Standard hardenability bands for 73 steels will be published in the 1949 Handbook for the first time. Included are 46 revised bands and nine new bands for the following steels: 2330H, 3120H, 3130H, 3135H, 4053H, 4337H, 4621H, 8653H, and 9310H. H-band steels are now standard rather than tentative, as previously designated, as the result of recent SAE Technical Board action. Two new steels added to the SAE standard list are 1049 and 1086.

COLUMBIUM SHORTAGE: Substitution of titanium type alloy for columbium, growing short in supply and being cut back by allocation agencies, was urged at a recent meeting of the SAE AMS Corrosion and Heat Resistant Alloys Committee. Titanium type alloy (AISI 321) was said to be suitable for applications in the aircraft industry where columbium type alloy (AISI 347) is being used. It was said that columbium in scrap is not recoverable since it is oxidized during remelting. To supply a given amount of columbium in a final alloy engine part, about three times that amount of virgin metal is required.

VEHICLE FUSES: The SAE standard for automotive electric fuses is being revised by a subcommittee of the SAE Electrical Equipment Committee. Among the changes being proposed is the rating of fuses for amperage capacity at 32v instead of 25v. Also being contemplated is a larger-diameter hole for the tubular gage through which the completed fuse must pass.

TRUCK NOISE: Noisy commercial vehicles were traced partly to drivers by fleet operators at a recent meeting of the SAE Automotive Traffic Noise Subcommittee. According to these reports, drivers like the noise their vehicles create and, in some cases where they are not controlled, drivers render mufflers inoperative.

CIGAR LIGHTER STANDARD: Dimensional standards for cigar lighter standards and accessory plugs in cars are being worked out by a subcommittee of the SAE Electrical Equipment Committee. Purpose of such a standard is to prevent the plug from damaging the receptacle rather than to specify plug performance.

CARBURETORS: The SAE Engine Committee has organized a subcommittee to develop carburetor air intake dimensional standards in the light of substantial industry interest in the subject. A. H. Winkler, Eclipse Machine Division, Bendix Aviation Corp., will chairman the new group.

TRUCK INSTRUMENTS: The SAE Motorcoach and Motor Truck Committee has assigned a subcommittee the job of probing possibilities of recommending relative positions for instruments on the instrument board. Scope of this project is limited to applications where individual instruments—not in clusters—are used.

IGNITION CABLE: In discussing high-temperature-resistant cable for aircraft ignition systems at a recent meeting, the SAE Ignition Research Committee considered the use of silicones. One type of silicone material under development may be used in a temperature range of from −100F to 300F. These temperatures can be applied continuously. Most silicones, it was pointed out, can withstand temperatures of 500F for intermittent periods. Teflon, another material suitable for ignition cable, was said to withstand temperatures 50 to 100F higher than silicones; its main drawback appears to be cost.

European and American headlamps for the Automobile Manufacturers Association. These tests are being conducted in connection with efforts of the International Commission on Illumination and Technical Committee 22 on Automobiles, of the International Standards Organization, to achieve uniformity of lighting standards of various countries.

Object of these tests is to provide comparative data on seeing distances with American and European headlamps. Unfortunately, available data are not comparable because different test procedures were used. The European practice is to test with the vehicle stationary while in this country tests are made with the vehicle moving. Comparative data obtained from moving vehicle tests will be used as a basis for the SAE Lighting Committee report.

protection for full-scale engines than the use of pure hydrocarbon reference fuels, the report says.

Evaluation of knock quality at two or more intake air temperatures provides an additional and more direct check on fuel sensitivity than previously available, it is pointed out.

The report recommends:

● Further work be carried out by some other CRC group to determine if tests run in a number of engines in different laboratories would substantiate the Panel's conclusions based on the two engines tested,

● That the 30 deg overlap camshaft be redesigned to give smoother valve action, and that hydraulic valve lifters be used, and

● Consideration be given to the requirements necessary to insure proper evaluation of fuels of the highest antiknock quality.

The report, which explains the techniques used in the test program, outlines the proposed research method and states conclusions, consists of 38 pp., 8½ x 11 in., and includes charts and drawings.

Available from the SAE Special Publications Department, 29 West 39 Street, New York 18, N. Y. Ask for CRC-228. Price: $2 to SAE members, $4 to nonmembers.

New CRC Technique For Fuel-Knock Tests

IMPROVED method of comparing the knock characteristics of aviation fuels in the range of 91 octane number to 160 lean performance number is disclosed in a recently issued report of the Coordinating Research Council now available.

The report, "Knocking Characteristics of Aviation Fuels: Jan. 21, 1948, Revised March 10, 1948," points out that the study of higher antiknock fuels will require modifications of the present equipment in order to establish a more complete evaluation of their detonation characteristics.

Use of a point-by-point comparison technique will provide improved reproducibility over the F-4 procedure at lean mixture, it was pointed out.

The new technique provides a measure of fuel quality at both lean and rich mixtures, and gives adequate separation of fuels.

Use of commercial type reference fuels whose performance is fully evaluated in full-scale engines, and whose sensitivity characteristics are similar to commercial fuels, will provide greater

Release New Standards For Propeller Shafts

A series of 10 SAE standards for propeller shaft ends and adapters for low-horsepower aircraft engines recently was approved by the Technical Board. Developed by the SAE Small Aircraft Engine Propeller Shaft Committee, under Herb Rawdon, Beech Aircraft Corp., these standards are:

1. AS 126A—Propeller Shaft End. Taper Type— No. 0. This is a revision of AS 126, expanded with two more drawings to show dimensions more clearly.

2. AS 127A—Propeller Shaft End, Flanged Type—Nos. 1, 2, 3, and 4. This is a revision of AS 127 to which the No. 4 propeller shaft end has been added.

3. AS 357—Hub, Wood Propeller. Taper Type—No. 0.

4. AS 359—Nut, Propeller Hub, Taper Type—No. 0.

5. AS 360—Snap Ring, Propeller Hub, Taper Type—No. 0. (AS 357, 359, and 360 are dimensional standards.)

6. ARP 373—Propeller Shaft Torque Ratings. Listed here are recommended allowable ratings for propeller shaft ends for low-horsepower engines. The recommended rating equals rated pro-

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Upham Retires After 20 Years As F & L Committee Chairman

AFTER 20 years of distinguished service as chairman of the SAE Fuels & Lubricants Committee and of its predecessor, the Lubricants Division of the former SAE Standards Committee, E. W. Upham, Chrysler Corp., retired from office at the Jan. 12 meeting of the Committee. He is succeeded by M. D. Gjerde, Standard Oil Co. of Indiana.

Members of the Committee, of the Technical Board, and the Society joined in an engrossed resolution expressing their appreciation for Upham's outstanding contributions. He will continue to serve on the Committee and as a member of its Executive Committee.

Committee Chairman Gjerde was vice-chairman of the group. The job he vacated is being filled by J. M. Campbell, Research Laboratories Division, GMC.

E. W. Upham

M. D. Gjerde

Members and guests of the Editorial Subcommittee, of ASA Sectional Committee on Standardization of Screw Threads, B1, at its January meeting in Detroit, ironed out minor details that lead to approval of the revised American Standard for Screw Threads. They are (seated, left to right): C. G. Davey, AC Spark Plug Division, GMC; W. C. Stewart, American Institute of Bolt, Nut, and Rivet Manufacturers; H. W. Robb, General Electric Co.; F. K. Brown, Continental Screw Co.; F. P. Tisch, Phoell Mfg. Co.; I. H. Fullmer,

National Bureau of Standards, chairman; W. H. Gourlie, Sheffield Corp., secretary; F. E. Richardson, Munitions Board; H. Marchant, Chrysler Corp.; and P. M. Delzell, Ford Motor Co.

(Standing, left to right): R. F. Holmes, AC Spark Plug Division, GMC; H. R. Cobleigh, and S. A. Tucker, ASME staff; R. S. Burnett. SAE staff; P. V. Miller, Taft-Pierce Mfg. Co.; G. M. Aron, Northrop Aircraft, Inc.; and W. L. Barth, General Motors Corp.

New Tolerance Classes Added
to American Screw Thread Standard

APPROVAL last month of a revision in the American Standard for Screw Threads gives industry new classes of tolerances worked out so that threaded parts will assemble with an allowance or clearance. Additionally, the modifications carry out recent agreements with the British and Canadians on a unified and interchangeable screw thread practice, as reported in the January SAE Journal. This Standard is sponsored by SAE and ASME.

New tolerance classes in the Standard are 1A and 1B, 2A and 2B, and 3A and 3B (A for the external thread and B for the internal thread). A moderate allowance or clearance is applied on Classes 1A and 2A. All classes are consistent with each other, being based on the tolerance for Class 2A, which is derived from a formula.

Revisions in Standard

The revised Standard includes these six new classes in both the Coarse and Fine Series; they agree with what the British will publish. These pitch and class combinations are designated UNC and UNF—interpreted in this country as Unified National Coarse and Unified National Fine, respectively; in Britain, as Unified Coarse and Unified Fine.

The UNC and UNF designations apply only to threads ¼ to 4 in. in the Coarse Series and to threads ¼ to 1½ in. in the Fine Series.

Numbered sizes and larger diameter threads are continued as NC and NF in

the Standard. The old Classes 2 and 3 also are retained in the American Standard, as are the numbered sizes and special threads.

The new tolerance classes are an outgrowth of automotive interest in a thread that eliminates both galling and seizure in high-cycle wrenching and difficulties with plated parts.

The American-British-Canadian accord, signed on Nov. 18, 1948, was based on these new classes and included agreement on thread angle, thread form, and pitch.

SAE Screw Thread Standards have been revised to conform with the revised American Standard for Screw Threads.

Committee Personnel

THE following appointments were made by the SAE Technical Board at its January meeting in Detroit:

● A. G. Herreshoff, Crysler Corp., as sponsor of the SAE Automotive Drafting Standards Committee, succeeding D. G. Roos, whose term on the Board expired.

● R. E. VanDeventer, Packard Motor Car Co., as SAE representative on the Inter Society Corrosion Committee, of the National Association of Corrosion Engineers.

● O. E. Kirchner, American Airlines, Inc., as an additional SAE representative on ASA Sectional Committee Z14—Drawings and Drafting Room Practice, with P. G. Clark, Propeller Division, Curtiss-Wright Corp., as alternate.

● W. I. Rodgers, Jr., ACF-Brill Motors Co., to succeed L. H. Smith as

one of SAE's five representatives on ASA Sectional Committee Z26—Specifications and Methods of Test for Safety Glazing Material.

The Technical Board also confirmed the following appointments:

● R. W. Roush, Timken-Detroit Axle Co., succeeds F. C. Young, Ford Motor Co., as chairman of the SAE Iron & Steel Technical Committee, (Roush was vice-chairman of the Committee last year), and M. L. Frey, Allis-Chalmers Mfg. Co., as Committee vice-chairman.

● E. N. Hatch, New York City Transit System, as chairman of the SAE Transportation and Maintenance Technical Committee, succeeding W. D. Bixby.

● G. J. Dashefsky and E. C. Noonan, Navy Bureau of Ships, as liaison members of the SAE Vibration Committee.

peller shaft torque (in foot-pounds) times the cylinder bore (in inches).

7. ARP 381—Hub, Flanged—Spline Type Wood Propeller—No. 10 and No. 20.

8. ARP 382—Bushing, Propeller Hub —No. 10 and No. 20.

9. ARP 384—Sleeve, Propeller Adapter—No. 10 and No. 20.

10. ARP 385—Cone, Wood Propeller Hub, Rear—No. 10.

In addition to these standards, 10 others for aircraft engine and propeller utility parts were approved. Included in this group were standards for round and flat slotted-head screws and for engine accessory drive gaskets.

ISO Hague Meet Reported by Hunt

J. H. HUNT, General Motors Corp., recently reported to the SAE Technical Board on the meeting of the Committee of Automobiles, of the International Standards Organization, at The Hague, Holland, last October. Designated by SAE as American representative to the ISO meeting, Hunt advised that European delegates were generally receptive toward SAE lighting standards as a basis for modifying their national standards, and that SAE proposals for metric spark-plug threads were receiving careful consideration.

Although the lighting group at the meeting drafted a basis for standards for the semaphore-type turn indicator generally used in Europe, it also accepted an alternate based on the SAE specification for the flashing-lamp type.

SAE specifications for Sealed Beam dimensions also were accepted as a basis for "built-in" headlamps.

Hunt reported that some delegates considered logical SAE proposals for metric-size spark plugs and favored their adoption; but obstacle to this, they claim, is the fact that a considerable number of European engines in service cannot receive plugs made to maximum proposed SAE dimensions. However, the SAE proposal is being studied.

All action taken at the meeting is subject to approval by letter ballot.

Another interesting item emerging from the ISO meeting was word that the United Nations Organization is drawing up a "Code de Route," covering conditions under which vehicles would be permitted to tour outside of the owner's country. It is planned that the code become an international convention under UNO whereby all countries will be obligated to permit vehicles to tour within their respective boundaries, provided the vehicles conform to the code.

You'll Be Interested to Know . . . .

SAE MEMBERS ARE INVITED to attend the First International Aeronautical Industries Meeting in Paris in May.

Sponsored by the Union Syndicale des Industries Aeronautiques (representative body of the French aircraft industries), the meeting will have sessions on experimental aerodynamics, strength of materials, prototype construction, quantity production, powerplants, accessories and equipment, airports, and the human problem in the aeronautical industries.

Andre Charriou is general chairman of the meeting, and it is from him that the invitation has come for SAE members to attend.

DIMITRIUS GERDAN, chief engine engineer, Allison Division, GMC, has been named vice-chairman of the SAE Aircraft Powerplant Activity Committee for 1949 by Vice-President A. M. Rothrock.

SAE WILL BE REPRESENTED on the Planning Committee for Mechanical Engineering Societies Conference in March by T. L. Preble, Tidewater Oil Co. . . . and at the 19th Annual Safety Convention and Exposition in New York, March 29-31, by Austin M. Wolf.

REPORTING AS SAE REPRESENTATIVE to the International Automotive Congress held at Turin, Italy, last September, Henry L. Brownback writes in part: "SAE President R. J. S. Pigott's letter of good wishes made a profound impression on the assembly both of Italian and other European engineers. President Bianchi of the Associazone Tecnica dell'Automobile professed his profound appreciation of the letter, of the SAE for having a delegate present, and of the American people for the aid given them under ERP—which, he said, was permitting Italy to live in the present and to hope for the future."

SAE National

Hotel New Yorker
New York City
April 11-14, 1949

Inspection Trip

On THURSDAY, APRIL 14, at 9:30 a.m., buses will leave the Hotel New Yorker for an inspection trip to Wright Aeronautical Corp., Wood-Ridge, N. J., and Propeller Division, Curtiss-Wright Corp., Caldwell, N. J.

(Fare: $2.00 Round Trip)

MONDAY, April 11

10:00 a.m.

R. L. TEMPLIN, Chairman

A Review of Problems in the Life Evaluation of Airplanes
—J. M. JACOBSON, Glenn L. Martin Co.

"On-Condition" Maintenance
—RALPH GEROR, Northwest Airlines, Inc.

Prepared Discussion

(Sponsored by Aircraft Activity)

2:00 p.m.

JEROME LEDERER, Chairman

Aircraft Evacuation on Land—Equipment, Stowage, and Procedure
—O. E. KIRCHNER, American Airlines, Inc.

Developments in Search and Rescue
—LT.-COM. A. W. WUERKER, U. S. Coast Guard

(Sponsored by Air Transport Activity)

8:00 p.m.

D. J. JORDAN, Chairman

Nitromethane As a Monopropellant
—F. ZWICKY and C. C. ROSS, Aerojet Engineering Corp.

Flight Testing the Wright Typhoon Turbo-Prop
—R. R. TEMPLETON and M. P. CERVINO, Wright Aeronautical Corp.

(Sponsored by Aircraft Powerplant Activity)

Aeronautic & Air Transport Meeting
and Aircraft Engineering Display

TUESDAY, April 12

ALL-DAY PANEL DISCUSSION—

"Getting the Best Out of Our New Transports"

General Chairman—WILLIAM LITTLEWOOD, American Airlines, Inc.

9:30 a.m.

Chairman—W. E. BEALL, Boeing Aircraft Co.

Panel Members	Discussing
P. C. SCOFIELD AiResearch Mfg. Co.	Heating, Ventilating, Pressurization and Air Conditioning
E. S. GALLAGHER General Electric Co.	Electrical System
R. A. BROWN Minneapolis-Honeywell Regulator Co.	Automatic Equipment
JAMES ROBINSON Vickers, Inc.	Hydraulic Equipment
J. B. FRANKLIN Capital Airlines, Inc.	"Heckler"

(Sponsored by Aircraft Activity)

2:00 p.m.

Chairman—R. L. EARLE, Propeller Division, Curtiss-Wright Corp.

Panel Members	Discussing
P. D. DORAN Pratt & Whitney Aircraft Engines, United Aircraft Service Corp.	Engines
C. F. BAKER Hamilton Standard Propeller Div., United Aircraft Corp.	Propellers
H. G. TARTER Bendix Products Div. Bendix Aviation Corp.	Carburetors
W. V. HANLEY Standard Oil Co. of California	Fuels and Lubricants
J. G. BORGER Pan American World Airways	"Heckler"

(Sponsored by Aircraft Powerplant Activity)

8:00 p.m.

Chairman—J. C. LESLIE, Pan American World Airways

Panel Members	Discussing
A. E. RAYMOND Douglas Aircraft Co., Inc.	Airplane
R. W. YOUNG Wright Aeronautical Corp.	Powerplants
D. E. FRITZ Jack & Heintz Precision Industries, Inc.	Equipment
CHARLES FROESCH Eastern Air Lines, Inc.	Airlines
K. R. FERGUSON Northwest Airlines, Inc.	Summary

(Sponsored by Air Transport Activity)

WEDNESDAY, April 13

9:30 a.m.

R. R. HIGGINBOTHAM, Chairman

A Method of Evaluating Powerplants for Use in Subsonic Transport Airplanes
—H. M. HENNEBERRY and A. F. LIETZKE, National Advisory Committee for Aeronautics

Fuel Systems and Carburetors for Personal Aircraft
—S. B. SMITH, A. J. VOLZ, and M. R. BALIS, Bendix Products Division, Bendix Aviation Corp.

(Sponsored by Aircraft Powerplant Activity)

2:00 p.m

MAJOR RAYMOND HAJEK, Chairman

Review of Transport Aircraft Developments During the Past Two Years and Some Predictions for the Future
—R. C. LOOMIS, Consolidated Vultee Aircraft Corp.

Landing Gears—Past, Present and Future
—T. J. BAKER, Air Materiel Command, Wright Field

(Sponsored by Aircraft and Air Transport Activities)

——————— DINNER ———————

6:30 p.m.

Welcome—R. C. Long, Chairman, SAE Metropolitan Section

Toastmaster—Ralph S. Damon, President, Trans World Airline

S. W. Sparrow, SAE President

Presentation of Wright Brothers Medal to
K. E. Van Every
by W. E. BEALL

Air Force Activities in Rockets, Jet Propulsion, and Supersonic Flight
Gen. Joseph T. McNarney,
USAF Commanding General, Air Materiel Command

WOOD

KELLEY
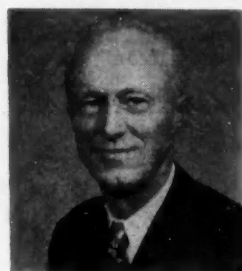
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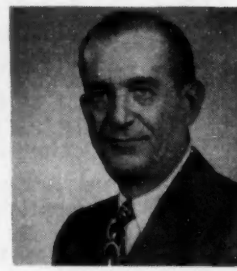
COLLINS

Chevrolet Changes

JOHN G. WOOD has been appointed executive assistant to the general manager for engineering at the Chevrolet Motor Division, Detroit. He was chief engineer from 1945. EDWARD H. KELLEY, assistant chief engineer, succeeds Wood as chief engineer of Chevrolet. Wood is an SAE past vice-president and is currently a member of the SAE Public Relations Committee. Kelley is chairman of the SAE Passenger Car Meetings Committee. R. J. WATERBURY, who was staff engineer on both commercial and passenger car bodies and sheet metal design, is to be chief assistant engineer in charge of design—executive and administrative engineering. He is an SAE past vice-president and past chairman of the Detroit Section. P. A. COLLINS will be chief assistant engineer in charge of production and experimental engineering

About

W. H. CURTIS, resident engineer, Thompson Products West Coast Fuel Systems Laboratory, Inglewood, Calif., has requested that he be relieved of regular duties in the Inglewood office. The company has prevailed upon him to accept the status of consulting engineer.

HAROLD H. HALL has been made general service manager for the Cummins Engine Co., Inc., in Columbus, Ind. Previously he was manager of the Cummins Diesel Sales Corp. in St. Paul, Minn.

STEPHEN du PONT was recently appointed service manager of the Bellanca Aircraft Corp. in New Castle, Del.

O. E. HUNT, executive vice-president of General Motors Corp. and HUGH DEAN, manufacturing manager of the Chevrolet Motor Division, have both received the President's Certificate of Merit, highest civilian award, in recognition of individual industrial accomplishments of World War II.

RALPH S. DAMON, who recently resigned as president of American Airlines, Inc., has been elected president of Trans-Continental & Western Air, Inc., effective Feb. 10. He had been with American 12 years except for two years as head of Republic Aircraft Corp., Farmingdale, L. I., N. Y.

H. O. MATHEWS has been appointed manager of transportation for Standard Brands, Inc., a new position combining fleet operation and transportation of products of the company. J. W. LIMPERT is now responsible for fleet maintenance for the company.

WILLIAM J. DUNN has been elected vice-president of Thompson-Bremer & Co., Chicago, manufacturers of Everlock fastening products. He has been sales manager of the Hydraulic Division, New York Air Brake Co. in Chicago.

PAUL E. HOVGARD has been appointed project engineer for all current flying boat projects of the Glenn L. Martin Co., Baltimore, Md. For the past year and a half he was general manager for Piasecki Helicopter Corp. Hovgard is an SAE Councilor for 1948-1949.

C. O. RICHARDS was recently appointed to the position of general sales manager over all divisions of the Standard Products Co. His former post was general manager of the company's Reid Division in Cleveland, Ohio. In 1935 Richards was SAE Passenger Car vice-president.

NEIL A. MOORE is now vice-president in charge of the Federal-Mogul Service Division, with headquarters in Detroit. Moore joined Federal-Mogul recently, after serving for 24 years with the Sealed Power Corp.
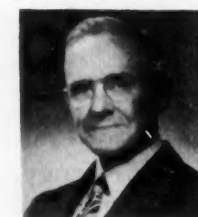
THOMAS L. COWLES has retired as export engineer for Studebaker Corp., after 20 years of service. Cowles has been connected with the automotive industry since 1905 and joined Studebaker in 1929 as chassis engineer on commercial vehicles. He was later transferred to the Passenger Car Division. After World War II he became export engineer, having been aviation engineer during the war.

RICHARD L. GATES has joined the Development Engineering Department of Thompson Products, Inc., Cleveland, Ohio, as a design engineer. Prior to this post, he was connected with the Electric Auto-Lite Co.

WALTER O. BRIGGS, board chairman of the Briggs Mfg. Co., Detroit, has received the Certificate of Merit from President Truman. The award was made in recognition of the firm's production of wings and turrets for B-17 bombers during the war.

DONALD B. BROOKS, since 1943 chief of the Automotive Section of the National Bureau of Standards has been named chief of the Engine Fuels Section with the dissolution of the former section. **CLARENCE S. BRUCE**, formerly assistant chief of the Automotive Section has been appointed assistant chief of the Engines & Lubrication Section under **SAMUEL A. McKEE**, chief. **J. T. DUCK** and **A. R. PIERCE** are also in McKee's section. **ALBERT D. BELL** has accepted a position with U. S. Naval Ordnance Laboratory, White Oak, Md.

WALLACE J. SQUIRE, has announced that Neapco Products, Inc., is the new corporate title of the former New England Auto Products Corp., Pottstown, Pa. Squire is the chief engineer of the company.

S. M. LAUDERDALE is now associated with Pierce Governor Co., Inc., of Anderson, Ind., as consulting engineer.

R. T. HOWE, now factory manager at LeTourneau, Inc., Vicksburg, Miss., had been plant engineer for the Drackett Co. in Cincinnati, Ohio.

ROBERT W. STREHLOW, who was recently graduated from the University of Wisconsin in Madison, is an engineering trainee at the Koehring Co. in Milwaukee.

JOHN GELB is associated with the A. O. Smith Corp. in Milwaukee, as senior design engineer.

GEORGE W. BRADY, chief engineer of the propeller Division of Curtiss-Wright Corp., has received the Sylvanus Albert Reed Award from the Institute of the Aeronautical Sciences. This award was presented to him "For his contribution to the development of the reversing propeller resulting in shorter landing runs for large aircraft."

JOSEPH ZUBATY, a former chief experimental engineer for AC Spark Plug Division, Flint, Mich., and for the last 15 years desiging engineer and manager of the Tractor Department of Skoda Works, Ltd., in Pilsen, Czechoslovakia, was ousted from Skoda when the Communists took over and is now in the U. S. Zone of Germany, awaiting a visa to the United States.

CHARLES W. PERELLE has resigned as president of Gar Wood Industries, Inc., stating that his "job was completed." He has served as chief executive of the Wood firm for over two years. In the past he has been a vice-president of Consolidated Vultee Aircraft Corp. and the Hughes Tool Co. He has made no definite commitments for the future.

R. E. CARPENTER has recently been elected president of the Spicer Mfg. Corp. in Toledo, Ohio. He was previously executive vice-president of the corporation.

WILLIAM E. NINESS has been named vice-president in charge of sales for the Fuller Mfg. Co., Kalamazoo, Mich., and **THOMAS BACKUS** has been named vice-president in charge of engineering. Niness has been with Fuller since 1928, serving as sales engineer and later as sales manager. Backus joined the company in 1935 as sales engineer and served successively as assistant chief engineer and chief engineer

DAVIES

HOARE

KELLY

DAVIS

Consolidation of Engineering and Maintenance by United Air Lines at San Francisco involves personnel realignments affecting several SAE members. **W. W. DAVIES**, manager of aircraft engineering, and **W. P. HOARE**, general manager of maintenance, will be located in San Francisco. **R. D. KELLY**, formerly superintendent of Engineering Development, joins the staff of United Air Lines Vice President **J. A. HERLIHY**, as superintendent of Technical Development. Assisting Kelly in the technical development group is **R. L. McBRIEN**. **F. F. DAVIS**, formerly superintendent of Engineering Planning, has been transferred from Engineering and has been named engineering and maintenance assistant to Herlihy.

JAMES L. MYERS, president of the Cleveland Graphite Bronze Co., and **CLAUDE E. MURRAY**, executive vice-president of the Willard Storage Battery Co., have been elected, respectively, president and treasurer of the Associated Industries of Cleveland. More than 1000 manufacturing firms in the Cleveland area are members of this organization.

NAT HAYNES has joined Boeing Airplane Co. as a design specialist at their Seattle, Wash., plant. He was formerly connected with North American Aviation, Inc., in Los Angeles, and with Pratt & Whitney Aircraft.

FREDERICK G. MILES is chairman and managing director of F. G. Miles, Ltd., Redhill Aerodrome, Surrey, England.

WALTER M. DAVIES has become an engineering designer with North American Aviation, Inc., in Los Angeles. Previously he was an aeronautical engineer with the Civil Aeronautics Administration in Fort Worth, Tex.

ALLEN W. ROMIG recently became a layout draftsman for American Car & Foundry Co. in Berwick, Pa. His previous position was at Glenn L. Martin Co. in Baltimore, Md.

MAYNARD B. TERRY has been appointed vice-president of the American Brakeblok Division of the American Brake Shoe Co. His headquarters will continue to be located in Detroit. He was formerly general sales manager, and has served in various sales capacities since joining the company in 1943.

FREDERICK C. CRAWFORD, president of Thompson Products, Inc., has been listed among Cleveland's 20 most important citizens by the editorial staff of the Cleveland News. Crawford is a past-president of the National Association of Manufacturers.

PAUL W. LITCHFIELD (left) was awarded a sterling silver cigar box at a luncheon held recently at the Union League Club in New York City, in honor of his 50 years' service to the rubber industry. A. L. Viles, president of the Rubber Manufacturers Association, made the presentation. Litchfield has been with the Goodyear Tire & Rubber Co., Akron, since 1900, and is now chairman of the board. He became a member of SAE in 1911.

SAE Members Said . . .

"Whether the 'Hydro-Matic' or the 'Dynaflow' is the better transmission will be determined largely by evolution . . . largely determined by the price and general appeal to the customers. They are not substantially different from the standpoint of the user who is not very discriminating in his driving". . . . **ALFRED P. SLOAN**, chairman of the board, General Motors. Corp.

"I am expecting the industry in 1949 to pass all previous production records. I think production of cars and trucks should exceed 6 million". . . . **C. E. WILSON**, president, General Motors Corp.

JAMES H. COOPER has been made vice-president in charge of engineering at the McCord Corp. He started to work for the McCord company in 1910, and since 1935 has been works manager.

HAROLD H. LEONARD, former Detroit district manager of the Delco Appliance Division, General Motors Corp., has been appointed to the position of sales manager of the Equipment Division.

DR. H. L. GUY, secretary of the Institution of Mechanical Engineers, London, England, was created a Knight Bachelor by King George on March 1. Sir Guy, who began his engineering career in 1910 with the British Westinghouse Co., became chief engineer of the successor company's Mechanical Department until he resigned from Metropolitan-Vickers Electrical Co. when he was appointed secretary of the Institution. He won the Thomas Hawksley Gold Medal, and the Parsons Memorial Medal, among other high honors, for his contributions to engineering.

A. W. HERRINGTON, chairman of the board at Marmon-Herrington Co., Inc., Indianapolis, will return from a trip to London early in March. He is a past-president of the SAE.

MARTIN HERBERT, JR., is now reports editor at the NEPA Division of the Fairchild Engine & Airplane Corp. in Oak Ridge, Tenn. His previous position was project engineer at General Motors Corp., Proving Ground Section in Milford, Mich.

SAMUEL J. LEE is president of the newly-formed National Fleet Sales Corp. in Chicago. The company is going to specialize in fleet sales of automotive equipment. Lee was fleet sales manager for Ruby Chevrolet, Inc., Chicago, for the past 13 years.

HARRY S. EGERTON is now design engineer for the Chase Aircraft Co. in West Trenton, N. J. Prior to this position he was project engineer at Parsons Industries, Inc., Rotary Wing Division in Traverse City, Mich.

CHARLES P. TURNER, who had been plant engineer at the Richmond Radiator Co. in New Castle, Del., has become equipment engineer for the Wilson Contracting Co., same city.

REGINALD I. RICE, JR., recently became chief project engineer at Kiekhaefer Aeromarine, Inc. in Fond Du Lac, Wis. He was formerly affiliated with Aircooled Motors, Inc., in Syracuse, N. Y.

THOMAS R. PIERPOINT has become service manager for the Piasecki Helicopter Corp. in Morton, Pa. He had been with American Helicopter Co., Manhatten Beach, Calif.

ARNE D. ALVAR is now an aeronautical engineer with the Grumman Aircraft Engineering Corp. in Bethpage, L. I., N. Y.

Harold R. Towers recently became sales engineer for the Broadway Maintenance Corp. in New York City. He had previously been an industrial engineer at Becton, Dickinson & Co. in Rutherford, N. J.

JAMES H. COOPER has been promoted from works manager to vice-president in charge of engineering of McCord Corp., Detroit.

THEODORE A. KREUSER, service sales manager of Bendix Products Division, Bendix Aviation Corp., South Bend, Ind., has been elected president of the Automotive Electric Association, Detroit. He has held important posts in the 33-year-old automotive trade association in recent years.

EUGENE P. FAGER has been appointed vice-president and Industrial Department manager of Dearborn Chemical Co., Chicago. A graduate of the University of Illinois in 1916, Fager joined Dearborn's laboratory staff in 1920, became chief chemist in 1924, and was elected a director of the concern

in 1934. He had been assistant vice-president and technical director for the past eight years.

E. L. HEMINGWAY, for several years chief metallurgist for the International Detrola Corp. and more recently research engineer for the Gisholt Machine Co., Madison, Wis., has left the employ of the latter company. A frequent author at SAE meetings, Hemingway has been identified with the development of superfinish processes for the past 10 years. His papers have covered that work, phenomena of abrasion, and heat treating processes.

EARLE S. MacPHERSON, executive engineer of Ford Motor Co., described the evolution of present day passenger cars before the Works Engineering Association, West Lynn, Mass., on Feb. 21. Theme was the development steps behind the 1949 Ford automobile.

L. A. McDONNELL, the 1945-46 chairman of the SAE Hawaii Section, is in this country cooperating on the design of automotive equipment to be used in the Islands. He is consulting engineer for American Factors, Ltd., Honolulu.

OBITUARIES

HARRY E. SCHANK

Harry E. Schank passed away on Jan. 12, after a brief illness.

For 15 years he was chief engineer of the McCord Corp., Detroit, and was known as one of the leading heat transfer engineers of the Industry. He had been in the Engineering Division at McCord for 25 years.

DR. G. J. MEAD

Dr. G. J. Mead, one of the leading designers of aircraft engines in America and co-founder of the Pratt & Whitney Aircraft Co., passed away on Jan. 20 in West Hartford, Conn., after a long illness. He was 57 years old.

He developed the basic designs which were used for production of half the aircraft engines used by this country's armed forces in World War II, and he established the Aircraft Production Section of the War Production Board.

In 1939 Mead retired as vice-president and chief engineer of United Aircraft Corp. He received the Sylvanus Albert Reed Award that year for his technical contributions to the advancement of aviation and his professional and business experience in both the technical and management fields.

OTIS ALLEN KENYON

Otis Allen Kenyon of Greenwich, Conn., died Feb. 3 in Nassau, Bahamas, while on a vacation. He was chairman of the board of Kenyon & Eckhardt, Inc., advertising agency, which he founded in 1929. He was 69.

He was educated in France, Germany, and was graduated from Cornell University with a degree in mechanical engineering in 1904.

His interest lay in electrical engineering, and he was granted a number of patents for welding equipment and in 1913 was appointed chief engineer of Arc Welding Machine Co. Three years later he joined the Society.

He invented the welding system for building the Liberty engine during World War I, and the device used for welding the steel lining of the Catskill Aqueduct.

Kenyon was editor and co-author of the Standard Handbook for Electrical Engineers, wrote numerous technical papers, and translated French and German technical works.

DEAN MILTON GILLESPIE

Dean M. Gillespie, Colorado dealer for White Motor Co. and farm industrial machinery, died Feb. 3 in Johns Hopkins Hospital, Baltimore. He was 64.

He was elected Representative to Congress from the Denver district on March 7, 1944 on the Republican ticket, and was reelected for the full term as member of the 79th Congress.

Gillespie had been an ardent civic worker and two years ago established the Dean Gillespie Foundation to carry on his philanthropic work. He joined the Society in 1932 and was largely responsible for the SAE Colorado Group.

Washington Section
Tries to Stump Experts

• Washington Section
J. T. Duck, Field Editor

Jan. 11—Members of the Washington Section were invited to "Stump the Experts" at a regular meeting, and they posed questions in many fields.

The panel of experts was headed by **Clarence S. Bruce**, heat and power division of the National Bureau of Standards. Other members of the panel were **Oscar Wiederhold**, Public Roads Administration; **Paul Hollowell**, Civil Aeronautics Administration; **Dr. Ernest F. Fiock**, chief, combustion research section, National Bureau of Standards; and **Walter C. Bauer**, chief engineer, Briggs Filtration Co.

The problem that attracted greatest interest was automotive lubrication. When asked how often oil changes are necessary, Bauer replied, "I never change oil." He told of operating a car for 49,000 miles without a change of crankcase oil. At the end of this period, no part of the engine appeared to be damaged by improper lubrication. The "experts" agreed that oil changes should be less frequent than is the general practice. It was recalled that a recent regulation in regard to servicing government-operated vehicles specifies oil changes each 4000 miles instead of the previous requirement of changes each 1000 miles.

During a discussion of gasoline quality, the members of the panel stated that most of the difference in premium and "high-test" gasoline is in antiknock quality. Most cars in current production, it was said, are designed for operation on regular-grade

gasoline. The slight ping encountered under heavy load may be objectionable with respect to noise but will not measurably affect power or fuel consumption. The difference in premium- and regular-grade gasoline is, for the average motorist, in cost per gallon. The premium-grade fuel gives better antiknock performance but is no better with respect to other important properties that are inherent in good gasoline.

Fiock reviewed briefly the development of gas turbines. Most of the commercial development has thus far been confined to comparatively large units. A Swiss railroad has been using a turbine-powered locomotive since before the war. American railroads are interested in turbine development and in cooperation with allied interests have at least two units under construction, though none is yet in service.

Discussion of aeronautic problems included several theoretical and practical problems. The "sonic barrier" was defined as being the result of shock waves on the leading edges of the wings. The shock waves increase the friction very rapidly so that the power requirement of the plane is increased several times in passing through a comparatively narrow speed range.

Hollowell told of experiences of the CAA in investigating fatal accidents. The recent disastrous fires in a certain type of four-motored airliner presented the most difficult problem in recent years because, starting in midair, the fires left few clues as to their origin. Finally it was found that the fires originated from raw gasoline bleeding from an air vent into the inlet of a combustion-type heater. The planes of this class were immediately

grounded until the defect in design was corrected.

Bruce, in response to a question about gadgets for improving engine efficiency, stated that no gadget can improve engine performance unless it changes the basic design of the engine. The National Bureau of Standards, he pointed out, has tested hundreds of such devices, but has never found one that makes an improvement that cannot be more conveniently and less expensively accomplished by proper adjustment of standard equipment supplied by the manufacturer.

Former Chairman's Son
Talks on B & M's Diesels

• New England Section
A. R. Okuro, Field Editor

Dec. 7—**Ralph G. Fritch**, son of former New England Section Chairman Howard Fritch, provided a number of glimpses of the Boston & Maine and Maine Central Railroads' diesel locomotive operation and maintenance.

At present, these railroads operate 151 diesel units, which cost a total of $16,705,682.96. A program of inspection, preventive maintenance, and service for the 2294 cylinders is carried on in facilities at Boston, Mass., and Mechanicsville, N. Y. Facilities include pits, depressed floors, and special rooms set up for the operation of detached units, Fritch said, adding parentheti-

caily that trucks and motors are serviced at North Billerica, Mass.

Progressive maintenance between runs permits operation with a definite reduction in lay-up time and provides almost 100% availability.

Diesel locomotives handle 88% of the gross-ton-miles in freight and 55% of the car-miles in passenger service. Steam locomotives move the balance of freight and passenger trains in shorter hauls and commuter service, he said.

A disadvantage in diesel-powered passenger service is the necessity of using auxiliary steam generators for car heating. These units require close supervision for satisfactory operation. Another important consideration is the training of engine crews. Some problems have been encountered since the nomenclature relative to diesel-electric equipment is foreign to steam training. Despite the obstacles of seniority and bidding, all engine men are qualified with regard to safety and time tables. However, it is apparent in some categories that railroad training is restricted by the apprentice system, and the question of "who does which to what" is ever present, according to Fritch.

Production Experts
Tell of New Methods

● Detroit Section
W. F. Sherman, Field Editor

Dec. 13—The Production Activity presented three experts to discuss the important problem of synchronizing production.

The speakers were **O. E. Johnson**, Kaiser-Frazer Corp.; **H. P. Henderson**, New Departure Division, GMC; and **I. J. Haus**, Nash-Kelvinator Corp.

Johnson, assistant general production manager of his company, highlighted materials handling methods at Willow Run. Inflated costs of inventories and the psychological attitude of labor have both increased the importance of materials handling by mechanical methods, he said.

The goal is to make certain that inventory is controlled and turned over quickly and accurately, and that it is handled mechanically. With illustrations he demonstrated methods being used now, including methods worked out cooperatively with vendors to permit them as well as the vehicle manufacturer to handle and control inventory by mechanical means. Expendable and returnable packs were shown; various types of cartons and pallets were depicted.

At New Departure, which Henderson serves as assistant to the general manufacturing manager, practices of particular interest were illustrated by a motion picture showing a plant at Sandusky, Ohio, which manufactures automotive sizes of ball bearings. Close-tolerance manufacturing is aided by efficient material handling, the speaker said.

All types of conveyers, special motorized equipment for positioning parts handy to the operator, use of automatic tongs in crane handling, electric fork trucks, and use of special containers, were covered. Matched bearing parts are completed as finished bearings on continuous assembly lines.

Haus, plant engineer of the Nash body division, summarized the type of equipment used for materials handling for door fabrication. In the plant at Milwaukee, door panels are handled from the press room through final assembly by conveyers. Trolley conveyers and slat conveyers are employed.

Joseph Geschelin, Chilton Co., vice-chairman of Production Activity, presided at the meeting. A non-dinner affair, it was followed by a social hour.

Hp-Weight Ratio
Rises in Tractors

● Chicago Section
P. P. Polko, Ass't. Field Editor

Feb. 8—The trend in new models of industrial tractors is toward more power for the same size and weight, said **Harold T. Reishus**, general manager of the Industrial Power Division of International Harvester Co.

The greatest horsepower-to-weight increase is in rubber-tired tractors designed for off-the-highway big payloads hauling, Reishus reported.

The versatile crawler tractor has gained importance in earthmoving with more power, wider speed range, and greater ease of handling. It has become the backbone of modern construction industries. There are four major manufacturers in the business who make 24 basic models.

Transmission and steering are being improved, also.

Syracuse Section
Examines Dynaflow

● Syracuse Section
W. F. Burrows, Field Editor

Jan. 17—Center of interest at **Prof. Louis L. Otto's** talk on automatic transmissions was the cutaway Buick Dynaflow unit and a partially disassembled unit.

Otto, former Syracuse Section chairman, spoke before a joint meeting of the SAE section and the Technology Club of Syracuse on the story of transmissions from selective gear boxes to torque converters.

Examining a dynaflow transmission at a joint meeting of the Technology Club of Syracuse and Syracuse Section of SAE are: (left to right) George F. Dunbar, Buick dealer; Prof. Louis L. Otto of Cornell, who lectured on the transmission; Charles B. Spase, Technology president; and Samuel Wolcott, Syracuse Section chairman
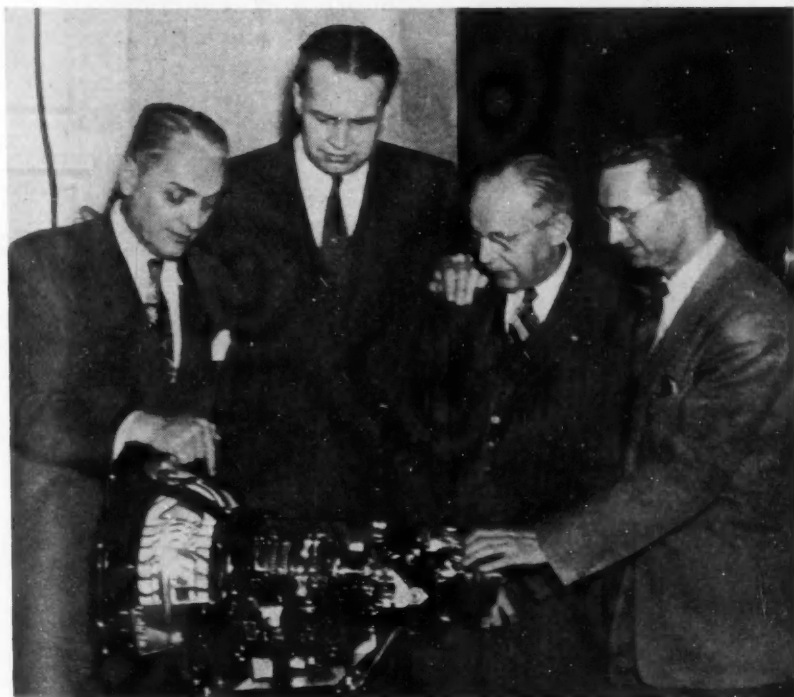
Automobiles Average
433 Rubber Parts Each

● Chicago Section
Clark Lupton

Jan. 17—Current models of automobiles average 433 rubber parts, and more rubber parts will make future automobiles better, predicted **E. F. Riesing**, Firestone Industrial Products Co.

Riesing displayed exhibits of actual parts and photographs of rubber engine mounts for nineteen 1949-model passenger cars. The display showed considerable differences in construction and location of engine mountings.

Present-day engine mountings represent a low-cost means of supporting the powerplant and serve to prevent objectionable vibration from being transferred to the car frame and body from engine rotative unbalance and combustion unbalance, Riesing said.

Engine mount material must be selected carefully, he warned. Prolonged low temperature crystallizes neoprene, making it undesirable for mounts.

The hydraulic brake system owes its success almost entirely to its rubber parts, according to Riesing. Rubber serves in the car's interior, too. Foam rubber cushions are becoming increasingly popular and are expected to be standard soon.

Looking over a display of rubber engine mounts at Chicago Section's Jan. 17 meeting are: (left to right) G. C. Vanderberg, E. F. Riesing, and SAE President S. W. Sparrow

Treiber Discusses
Automotive Diesels

● Chicago Section
E. A. Comfield, Field Editor

Dec. 16—Color of diesel-engine smoke is a clue to its origin, said **O. D. Treiber**, consulting engineer for Hercules Motors Corp., in his analysis of the application of diesel engines.

White smoke, he said, is usually formed when combustion is weak, as during cold starting. Blue smoke is the result of liquid fuel impinging on surfaces too cold to gasify it. The aldehydes produced under these conditions give a sickening smell to the exhaust. Black or dark brown smoke is largely colloidal carbon particles. As much as 18% of the fuel by weight can be lost into the air, according to Treiber.

Noise, one of the other topics considered, was defined as vibration frequencies between 100 and 16,000 cps.

It is most noticeable between 500 and 6000 cps.

Suppression measures consist of use of sound-deadening materials on firewalls, toe and floor boards, and intake air ducts. Exhaust noises can be reduced with efficient mufflers, but hack pressure should not exceed 2 in. of Hg at the exhaust flange.

Battery cable sizes for good starting should be not less than 00 for 5-ft or shorter lengths, 000 for 5- to 10-ft lengths, 0000 for 10- to 15-ft lengths, and two 00 for 15- to 20-ft lengths.

Research, Development
Stretch Defense Funds

● Southern California Section
R. E. Lindberg, Field Editor

Dec. 9—An Air Force research and development program has been initiated to make the most efficient use of the funds allocated for national air de-

Lt.-Col. L. W. Greenbank (left) listens while Southern California Section Chairman Jim Sinclair and Major-Gen. L. C. Craigie explain the Section's new public-address amplifier

SAE Section Chairmen

school. He won letters in football, baseball, track, tennis, cricket, soccer, and hockey. During 1923, 1924, and 1925, he was a member of the honored All-America cricket team.

Now his hobbies are golf, music, and movie photography, he says. The chef of Oklahoma City's Biltmore Hotel can vouch that Dan has another interest. The chef always expects a little added sampling supervision from Dan when Mid-Continent Section dinner meetings are held there.

—W. F. Ford, Field Editor

CUPIT
. . . . of Mid-Continent

C. W. "Dan" Cupit resembles Dan Cupid in more than nickname. Dan Cupit is a matchmaker, too—he specializes in matching solutions to technical problems.

Most of his problems are in petroleum chemistry. Currently his problems come to him via the Fuel Inspection Division of the Oklahoma Corporation Commission, which he serves as State Chemist.

At one time, he tackled the problems of designing, building, and operating a refinery for the manufacture of special lubricants. He has also supplied answers as a chief chemist in charge of automotive and chemical testing and refinery operational control.

During World War II, Dan was in Army Ordnance solving control problems in the manufacture of nitric acid, TNT, and special ingredients for aviation gasolines.

Besides SAE Mid-Continent Section, Dan applies his matching ability in ASTM's Division of Combustion Characteristics, CRC, North American Gasoline Conference, and the Chemists' Club.

He received his B.S. in Chemistry from The Pennsylvania State College. After studying chemical engineering a year on a fellowship at the University of Illinois, he received his master's degree from that school.

Dan was an all-round athlete in

HUNDLEY
. . . . of Northern California

Roy Hundley satisfied his wanderlust early and settled down to become an outstanding diesel engineer in his home town.

Directly after his graduation from Stanford University with a degree in mechanical engineering, he worked his way around the world on a Dollar Steamship Line boat.

He came home to San Francisco and started in with the Enterprise Engine and Foundry Co. as a detailer in 1935. He progressed rapidly through layout and design assignments to the position of assistant chief engineer. Two years later, when he was still only 30 years old, he became chief engineer.

Diesel engineers know him through his activities in the Diesel Engine Manufacturers' Association, particularly in editorial work and on the chief engineers' committee.

Roy and his wife have two sons.

—F. G. Wildhagen, Field Editor

SANBORN
. . . . of San Diego

Dan Sanborn has packed the 11 years since his graduation from the University of California with a variety of engineering experience with aircraft and their powerplants.

His first post-graduation job was with the stress department at Lockheed Aircraft Corporation. From there he went to the Morrow Aircraft Co. to take charge of the stress department.

In 1942 he accepted a job with Ryan Aeronautical Co. where he has served as project engineer on the XFR-1 and worked on development of jet engines and afterburners.

He interrupted his service with Ryan to do some design work on 2-stroke cycle engines for McCulloch Motors Co. The possibilities of 2-cycle engines had appealed to him ever since his model-building days, and he still devotes some of his spare time to trying out his own ideas about them.

Two other interests, sailing and soaring, led him to build a sailplane, in which he accumulated 50 hr of flying time. Now he is diverting his spare time to building a home.

—L. E. Morgan, Field Editor

fense in the unification act of a year ago, Lt.-Gen. L. C. Craigie reported.

"Our strategic position in World War II enabled us to win," Craigie said, "because we had (1) great natural resources, (2) cooperative industry, (3) time with allies fighting, (4) isolation or distance factor. Now all the advantages that remain in any future war are the first two, and in a guided-missile attack without warning, these would not be advantages unless protected and usable."

All civilian resources have been organized through a 30-member Aircraft Advisory Board. Through intensive scientific education, military officers learn the capabilities and limitations of their complex modern equipment. The Wright Field Institute graduates 150 to 200 officers per year, and those with special aptitudes are selected for further specialized training; the Civil Instruction program furnishes 1300 reserve officers annually.

The proportion expenditure between research and development is 12% and 88% respectively, according to Craigie. The engineering division transfers military requirements into specifications that can be negotiated into contract form with industry, and the resulting product is tested by specialized units at Wright Field; New York; Florida; and Fairbanks, Alaska. The problems in the development of such a program resolve themselves into simultaneous development on all avenues.

Winterization devices must have capabilities in hot or cold operations, and temperatures from – 90 to 160 F must be controlled. Cold-weather problems include development of material like fuel hose, plexiglass, and equipment for personnel. Craigie said, "Temperature extremes often require preheating the preheater."

In the field of transport aircraft, a design conforming to Army needs for a 25-ton cargo aircraft is being developed, Craigie reported, together with a medium tank transport and detachable-fuselage loading and unloading facilities. The pure cargo transport has primary commercial value, and funds are not available for such development, according to Craigie.

All-weather flying has high priority. Regardless of weather, day-and-night flight has been maintained between the Electronic Intelligence Center in Wilmington, Ohio, and Washington, D. C., a distance of 380 miles, for over two years. "Stupid-proof" automatic equipment is also high on the priority list, according to Craigie.

He saw as significant trends in military aircraft development, the use of the gas turbine begun during the war and the development of atomic-energy plants for aircraft use. "Through the Engineering Development Center, we are on the threshold of a new era in flight from transonic to supersonic," Craigie said. Summarizing, he said we must as a nation (1) be capable of defending our existing facilities, (2) conduct an extensive peacetime research program, (3) encourage the civilian scientist to play an important role, (4) create extensive testing facilities, and (5) develop with the air age into the supersonic.

Thomas Discusses Diesel Locomotives

● Williamsport Section
H. W. Epler, Field Editor

Jan. 10—In changing from steam to diesel-electric locomotives, the New York Central System developed new methods of personnel training and a unique system of progressive maintenance, which were described by Fayette Thomas, assistant to the general superintendent, motive power.

In the changeover, according to Thomas, operating crews and maintenance personnel were kept intact and given diesel-engine training by means of an instruction car with cutaway sections, movies, and lectures.

This method of instruction proved unsatisfactory, however, and a complete setup of locomotive equipment, consisting of a single engine, flash boiler, controls, and other auxiliary operating equipment, was installed in an old dining car to make it a self-propelled unit. With this method of instruction, it was possible to simulate actual operation and give the engine crew practical instructions in handling larger units. The system proved so satisfactory that a second car was built.

Progressive maintenance in large measure accounts for the short time— 6 to 8 hr—during which passenger and freight locomotives are out of service, said Thomas in describing this system of inspection. Comprehensive records

are kept on each locomotive, itemizing points of wear and anticipated useful life before requiring attention of maintenance crews. When a locomotive is in the shop for inspection, only those points of wear are inspected which the records indicate should be inspected at that time. Life expectancy of various items of wear is initially recommended by the manufacturer of the equipment, he explained.

In addition to progressive maintenance, diesel-electric passenger locomotives are given a general overhaul every 1,250,000 miles and freight locomotives every 800,000 miles. Steam locomotives without progressive maintenance require a general overhaul every 275,000 miles.

Switch locomotives are not maintained on a progressive basis but are inspected periodically, Thomas continued. They are out of service not more than one week in 1,250,000 miles and usually accumulate 27,000 miles per month. For comparison, passenger locomotives accumulate an average of 27,895 miles per month.

A disadvantage of the diesel locomotive is misuse, resulting from the fact that the diesel engine can handle overloads far better than its accompanying electrical equipment, while a steam locomotive stops when overloaded. Slippage of the driving wheels, which is sometimes bad between speeds of 70 and 80 mph, accounts for the major portion of misuse resulting in damage to the electrical equipment, Thomas said. The maintenance station at Harmon, N. Y., overhauls approximately 70 traction locomotives a month, and 10 to 15% are damaged by misuse.

Actually there is no saving in maintenance between steam and diesel locomotives. The overall saving is due to the elimination of such things as water pans, roadside equipment, and maintenance of road, necessary for steam locomotives. The reduction in the number of stops for servicing and in the time required for inspection and maintenance enables the diesel-electric locomotive to meet faster time schedules.

During an interesting question period, Thomas pointed out that the principal type of drive is the diesel-electric but that some small switching engines have geared drives.

Diesel-electric locomotives are cheaper than all-electric drive due to cost of substations and other equipment necessary for the latter.

Work is being done on gas turbines, coal and oil burning, but is not far enough advanced to compete with the diesel.

Before conversion to diesels, dynamometer-car test runs were made on various parts of the system to determine grades and allowable loads in order to ascertain diesel locomotive requirements. In operation it was found that tonnage limits for each type of unit for each section of the system were more satisfactory than load meter values.

SAE and IAS Meet To Hear Kalitinsky

● Dayton Section
J. E. P. Sullivan, Field Editor

Jan. 18—**Andrew Kalitinsky** repeated his talk "Atomic Power and Aircraft Propulsion" before a joint meeting of the local sections of SAE and IAS.

"We have not manufactured an atomic powerplant for aircraft, but we can say now that the practical development of atomic energy as a source of power calls for the active co-operation of both scientists and engineers, in research institutions and industry, if an early and successful application of this power is to be made," said Kalitinsky, chief engineer of the NEPA Project, a Division of Fairchild Engine and Airplane Corp., at Oak Ridge, Tenn.

He went on to explain that the co-operation is needed on problems of heat transfer, canning—the protection of the uranium in the reactor against corrosion by the working fluid and prevention of the escape of radioactive fission products into the working fluid, reduction of shielding weight, provision for high landing weight, and the effect of radiation on aircraft construction materials.

Panel Discusses New Traffic Code

● Hawaii Section
Rene Guillou, Field Editor

Jan. 17—Density and speed of Hawaiian traffic have become comparable to mainland conditions, and Honolulu's new traffic code follows accepted mainland standards for that reason, said **Col. C. R. Welsh** in introducing a panel discussion on the new code.

Welsh is chief engineer of the city's traffic safety commission.

Legally, the city of Honolulu includes the reefs and atolls in a 540,000 sq-mile area of ocean. Its traffic problems, fortunately, are limited to the island of Oahu, where the passage of 45,000 vehicles per day through a single-level intersection is in ill accord with the tourist's picture of waving palms and sunny beaches.

Capt. Herbert Rego and Sgt. Joe Lee of the police department traffic division explained the vehicle equipment required by the law, pointing out

that shipping difficulties have delayed the arrival of dealers' stocks, and that enforcement of the code is being deferred until the necessary devices can be purchased locally.

Discussion from the floor brought out the problem faced by the sugar plantations, with fleets of large and heavy trucks in predominantly daytime, off-the-road service. These trucks, under the code, should be completely equipped with clearance and marker lights, reflectors, and illuminated signal devices. The treatment to which these vehicles are subjected in driving through the cane fields, and in loading and unloading, would result in excessive costs for installing and maintaining such equipment. Such trucks are little used on public roads or at night.

James Duncan of the Traffic Safety Commission indicated the desire of that organization to be informed of such matters and to cooperate in adapting the uniform code to local conditions. The meeting authorized Section Chairman McLaughlin to appoint a committee to confer with the Traffic Safety Commission on possible amendments to the code.

Films Show Air Races and Arabian Oil Works

• Colorado Group
D. H. Lamb, Field Editor

Jan. 17—At the Liberty Truck & Parts Co., the group saw a program of films. One showed the activities of the Arabian-American Oil Co. in Saudi-Arabia and another depicted the Bendix Air Races. Other films of nontechnical subjects completed the program.

Bus Torque Converter Maintenance Outlined

• New England Section
A. R. Okuro, Field Editor

Jan. 4—Tips on torque converter maintenance in transit buses were offered by **J. Henry Hickman**, regional service manager for coaches, GMC Truck & Coach Division.

He recommended that fluid be replaced every 25,000 miles, filters be cleaned at every inspection, turbine and pump pressures be checked every 12,000 to 15,000 miles, lines and casing be checked every 2000 to 3000 miles for leaks, and coolers be cleaned internally every 12 months and externally every 2000 to 3000 miles.

Satisfactory performance of the well maintained hydraulic transmission is particularly noticeable in operations where stops per mile—rather than miles per stop—are encountered, Hick-

man reported. Engine and turbine performance should be stall-tested every 12,000 to 15,000 miles with a tachometer to measure engine speed and a pressure gage to measure turbine fluid pressure.

Helps Customers Apply Dynamometers

• Washington Section
J. T. Duck, Field Editor

Dec. 13—"Dynamometry is an art—the art of applying a dynamometer to the problems of automotive service work," said **Roy S. Godbey**, Electric Products Co., who told of his company's experience in developing and marketing a chassis dynamometer for use in automotive servicing.

The company built its first dynamometer in 1941. Production was interrupted by the war soon after. However, during that brief experience it was learned that marketing practices in general use had given dynamometers a bad reputation among automotive service personnel.

"The industry," said Godbey, "was still in the infantile stage where all thought was apparently given to making a dynamometer that worked. Merchandising consisted almost solely of getting an order and shipping out a dynamometer. From that point on it was the customer's baby."

When the manufacturing program was reopened after the war, the company resolved to build an instrument that would not only work but one that would also meet the service needs of potential customers.

They believed that a successful dynamometer program would cover the problem of setting up for each customer a system of operation—setting up the dynamometer favorably in the place of business, controlling service operations, establishing operating rules and regulations, maintenance and servicing of equipment, and training the operator in diagnosis of engine performance.

"The various objectives we set up for the design of our dynamometer go back to one basic principle—that time and space are the most valuable considerations on any garage owner's or car dealer's operation," Godbey said.

Although the manufacturer has no control over what is done with the dynamometer by his customer, it is essential that he should be assisted in setting up a sound plan of operation.

Effective tools must be supplied to implement each customer's plan of operation—trained operators, test data sheets, advertising and promotional information, and service manuals. Continued supervision should be provided for every dynamometer purchaser in order that he may keep abreast of the times and not allow his work to fall into decay.

STUDENT NEWS

Northrop Aeronautical Institute

An airplane capable of using an atomic powerplant efficiently would weigh at least 200,000 lb, said Col. H. E. Metcalf, speaker at the meeting held Jan. 26.

Col. Metcalf, who worked on the Army's atom bomb project and is now patent attorney and chief of nuclear research for Northrop Aircraft, explained that it is the heat given off in the reaction that is used. The heat can be controlled effectively by introducing foreign bodies into the pile to reduce its activity.

One of the biggest problems, he said, will be the shielding of the pilot from the powerplant. At present, there are no shielding materials feasible for use in airplanes.

It was pointed out that atomic power would be desirable for guided missiles, except that the valuable unexpended fuel supply could not be recovered.

University of Wisconsin

Milwaukee Section sponsored and arranged the Student Branch's tour through the Gary works of Carnegie-Illinois Steel Corp. on Dec. 11.

The coke plant was the first stop on the tour of the plant itself, which is so large that the trip must be made in buses or cars — it covers 1400 acres and employs 22,000 persons. In the coke plant are 15 coke batteries, each containing 77 ovens. These batteries coke 500,000 tons of coal per month.

The magnitude of the operation can be pictured when it is noted that the city of Gary, population 100,000 plus, uses only 2% of the gas produced by these coke batteries in a month.

From the coke plant the caravan proceeded to the unloading docks, where the ore boats bring the ore from the Mesabi Range to be unloaded and stored. The company has its own slip, nearly a mile long, for unloading its boats.

Huge ore-boat unloaders which take 20 tons at a single bite can unload a 1400-2000-ton ore boat in about 3½ hr. Since the lake freezes up during the winter, the plant must stockpile enough ore to see them through the winter. This requires about 6,000,000 tons of ore. Most of this ore was in when the trip was made, for the last boat was to arrive that day.

After leaving the dock area, the tour went through the blast-furnace section, where there are 12 blast furnaces in a row working day and night. They say that this is the only plant in the world with so many furnaces. From the furnace section, the group was taken to the open-hearth furnaces. The No. 2 open-hearth happened to be the one visited, and it had three Bes-semer converters working to charge the open hearth.

At the wheel mill was seen the huge 20,000,000-lb forging press which forms a railroad-car type wheel from a solid steel blank in one pressing operation.

The final stop on the tour was in the blooming mill, where large billets of steel are rolled into flat steel slabs. The manipulation of the rolls is quite an art in itself, judging from what was seen on the trip. Here too, was seen the huge 8000-hp electric motor which is used to drive the rolling mill.

—R. W. Henke, Field Editor

Fenn College

"Packaged Nuclear Power Plants" was the main topic of discussion by Dr. J. A. Campbell, assistant professor of chemistry at Oberlin College, when he addressed the Fenn Student Branch and the Cleveland Section on Jan. 17.

He maintained that the charge in the atomic bomb weighs about 20 or 30 lb and is about the size of an outdoor baseball.

As a weapon of war, the atomic bomb is ranked fourth by the U. S. Army, and its best use is in warships, declared Campbell.

The ultimate temperature of the bomb is 1,000,000,000 C., and it needs to be exploded within only a mile of the target in order to obtain 100% effectiveness against houses, stated Campbell.

According to Campbell, an atomic cloud spray is more effective than the bomb itself, inasmuch as a city's entire population may be wiped out without destroying anything else.

Campbell also advanced the opinion that there is no possibility of operating motor vehicles on atomic energy because of the immense weight factor involved. The advent of a "breeder pile," a device for absorbing neutrons, has increased the available amount of atomic energy by a factor of at least 200, asserted Campbell.

—R. L. Pappas, Field Editor

A. & M. College of Texas

On Dec. 10, 1948, the Texas Section officers and members had as their guests the SAE Student Branch of Texas A. & M. College at a banquet at the Aggieland Inn.

Among those present at the meeting were J. W. Walker, Texas Section chairman, and the governing board. Following the banquet, Floyd Patras was presented with a scroll commending him on his service as past-chairman of the Texas Section.

After the banquet, the group reconvened in the petroleum lecture room, where they were joined by the student chapter of the Institute of the Aeronautical Sciences to hear a talk on the "Aims and Activities of the Personal Aircraft Research Center at Texas A. & M. College" by Fred E. Weick. Weick, a past vice-president of SAE representing aircraft engineering, is

now director of the Personal Aircraft Research Center at Texas A. & M. College.

—S. K. Wood, Field Editor

Northrop Aeronautical Institute

At a dinner meeting on Dec. 3, 100 enrolled students and their guests heard C. L. "Kelly" Johnson review the design and development of the P-80 jet airplane.

Johnson is chief research engineer of Lockheed Aircraft Corp. Visitors at the dinner included Southern California Section Chairman James Sinclair; Charles F. Thomas of Lockheed; Newton Baker, Allison Division, GMC; Fred Hosterman, Lockheed; and Mell Hall, former chairman of the NAI Student Branch and current program chairman for the Southern California Section.

Coming Events

Cont. from p. 60

H. M. Avery, Office of the Chief of Naval Operations.

March 17—Hotel Statler; meeting 7:45 p.m. Synthetic Lubricants in Military Aircraft—E. M. Glass and Bernard Rubin of Wright Field.

Mid-Continent—March 18

Tulsa, Okla. Time of dinner, speaker and subject to be announced.

Milwaukee—March 4

Milwaukee Athletic Club; dinner 6:30 p.m. Speaker and subject to be announced.

Mohawk-Hudson Group—March 16

Hotel Wellington, Albany, N. Y.; dinner 6:45 p.m. Meeting 8:00 p.m. Recent Automotive Observations Abroad —George A. Round, chief automotive engineer, Socony-Vacuum Oil Co., Inc.

Pittsburgh—March 22

Mellon Institute; dinner 6:30 p.m. Meeting 8:00 p.m. Electrical Equipment and Its Applications—J. H. Bolles, chief engineer, Delco-Remy Division, GMC.

St. Louis—March 8

Garabelli's, Adolphus Room; dinner 6:30 p.m. Meeting 8:00 p.m. What is Airline Engineering (illustrated with slides).—Charles Froesch, chief engineer, Eastern Air Lines. Technicolor motion picture film: Air Power Is Peace Power. Cocktails 6:30 p.m.

Southern New England—March 10

Hotel Bond, Hartford, Conn.; dinner

6:45 p.m. Meeting 8:00 p.m. Instrumentation as Applied to Development of the Wasp Major Engine—Robert E. Gorton, project engineer, Pratt and Whitney Aircraft.

Western Michigan—March 17

Hotel Occidental, Muskegon, Mich.; dinner 7:00 p.m. My Friend the Engine—Stanwood W. Sparrow, vice-president in charge of engineering, Studebaker Corp., South Bend, Ind., and president, SAE. Cocktails 6:15 to 6:45 p.m., sponsored through courtesy of Campbell, Wyant and Cannon Fdy. Co. Quartette singing.

Wichita—March 17

Droll's Grill; dinner 6:30 p.m. Radio Aids to Instrument Approach and Landing—R. C. Ayes, TWA. Film.

Williamsport Group—March 7 and April 4

March 7—The Antlers Club; dinner 6:45 p.m. The Elimination of Combustion Knock—E. M. Barbar, supervisor, engineering research at Beacon Laboratory, The Texas Co.

April 4—The Antlers Club; dinner 6:45 p.m. Airline Operation and Maintenance—John R. Griffin, Jr., manager of engineering, Newcastle, Delaware Overhaul Base, Trans World Airline.

Southern California—March 17

Rodger Young Auditorium, 936 West Washington Blvd., Los Angeles; dinner 6:30 p.m. Objectives in Truck and Bus Development—Merrill C. Horine, Mack Mfg. Corp.

Dynamic Plane Loads

Continued from p. 70

during a water landing and shears in an airplane wing during a gust.

Finding combinations of structure and exciting forces that produce significant dynamic loads is no easy determination. At present either pseudo-dynamic analyses of doubtful value or limited experience with dynamic analyses must serve as basis for judgment.

It is impractical to make rigorous analyses. Here is the approach recommended:

1. Make simplifying assumptions.
2. Neglect structural damping.
3. Use entire airplane modes.
4. Do not rely too much on accuracy of determination of higher modes. Generally their effects are slight; it is best to ignore them.
5. Keep the number of modes as small as possible. Eliminate even

those low modes which can be expected to have only small effects.

6. Omit coupling forces between the rigid body and elastic modes. Generally it is also satisfactory to omit coupling between various vibration modes when conditions do not approach flutter.

7. Include pitching in the analysis of flight conditions.

(Paper "Dynamic Loads on Airplane Structures," was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 15, 1948. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

New Members Qualified

These applicants qualified for admission to the Society between Jan. 10, 1949 and Feb. 10, 1949. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (Aff.) Affiliate; (SM) Service Member; (FM) Foreign Member.

Baltimore Section
Allen G. Barclay (J), Robert Morris Foster (J), John J. Smith (J).

British Columbia Group
Clement Edward Barnsdale (M), Edward Walter Higgins (A), Albert Murray Martin (A).

Canadian Section
Earl Aikin (A), James Campbell Brownlee (A), Brenton Wilbert MacKeen (M), Charles C. Stenhouse (A), Hubert Leslie Taylor (M).

Central Illinois Section
Charles S. Morris (J).

Chicago Section
Ralph L. Beyerstedt (M), Olin Brummer (M), W. C. Dyer (A), Edward John Gustaf (J), Eugene J. Hardig (M), Grant William Keller (J), Hugh G. Kepner (J), Alfred A. Krueger (A), Richard H. Long (M), Robert Roy Madson (J), William August Peter Meyer (J), Raymond Griffin O'Connell (J), Osmund Orland (J), Basil J. Ryder (M), Walter J. Samek (J).

Cincinnati Section
William Howard Bischoff (A).

Cleveland Section
Charles O. Burgess (M), Joe Conn (M), John B. Leece (M), Elmer H. Redding (A), Frederick H. Schmidt (M), Lewis Allen Schultz (J), Martin L. Sheetz (M), Daniel E. Votypka (J), Don C. Wilks (A), Richard F. Woodruff (A).

Colorado Group
John D. Cole (M).

Dayton Section
Roy C. Bodem (M), Harold Bonham Hensley (A), Floyd F. Lachey (J).

Detroit Section
George W. Awtrey (A), Frederick M. Baker (J), Hector J. Bourdeaux (A), Frank A. Colosimo (M), Harry K. Daniel (M), John R. Dunlop (J), John A. Egan (J), Robert P. Ernest (J), Leonard J. Evans (J), Aaron Friedman (J), Harlan Ray Greenman (J), Phil E. Haglund (M), Parker E. Holt (M), Donald Richard Kinker (J), Chester A. Kus (J), Harold N. Lepisto (J), George Miakinin (J), Albert E. Nash (J), Loren J. O'Brien (M), Henry Richard O'Hara, Jr. (J), Jim Andrew Plakas (J), Robert L. Rice (J), Richard B. Saltonstall (M), George W. Scharbach (J), Robert Serr (J), D. O. Sikes (A), Bruce H. Simpson (J), Robert Harman Smith (J), Arthur T. M. Southart (M), Keith Van Kirk (A).

Indiana Section
Robert William Heid, Jr. (J), Charles Mark Middlesworth (SM).

Metropolitan Section
Richard L. Akers (J), Robert O. Babcock (M), Vernon R. Bjorkman (A), David S. Brown (M), Anthony Frank Chaikowski (J), Robert M. Clough (M), Russell T. De Muth (J), Lindsay Dunham, Jr. (J), Thomas Dunlop, Jr. (M), Jules Louis Dussourd (J), J. M. Harris (A), J. Darrell Harvey (A), Robert E. Johnson (M), Austin Kuhns (M), Walter H. Langseder (A), Sidney S. Linn (J), John Marrotte (J), John M. McGinnis (A), Leo Pavelle (A), Dominic Recchione (J), Hugh S. Wagner (A), George W. Wunner (M).

Mid-Continent Section
Cameron L. Kerran (J), DeWayne Wilbur Lake (J).

Milwaukee Section
Stanley J. Backey (M), John M. Gerty (J), Floyd R. Kishline (J), Nicholas F. Ledanski (M), John J. Treutelaar (M).

Mohawk-Hudson Group
Edward W. Light, Sr. (M).

New England Section
Frederick L. Cole (A), Robert Edward Scherr (J).

Northern California Section
John D. Ainsworth (A), Henry M. Fujii (A), Corwin Duncan McLean (J), Raymond J. Miniet (J), Harry C. Sage (A), Alford R. Smith (A).

Philadelphia Section
Harry M. McCully, Jr. (J), Vytautas S. Mosinskis (M), William C. Schuster (A), Gordon T. Seng (J), John S. Snell (A).

Pittsburgh Section
U. G. Held (A).

St. Louis Section
Lawrence Bierman (J), Leonard A. Cromer, Jr. (J), Hulett Scott Ingersoll (J), Barclay F. Smith (M).

Salt Lake Group
William D. Osborne (A).

Southern California Section
Aubrey E. Austin, Jr. (A), W. Ellwood Jae (A), A. W. Koehler (A), Richard Charles Nelson (J), Don Vernor Rowton (J), Robert Stanford Schuyler (A), Robert Marquis Seeley (A), Robert Ware Sumner (A), Philip Daniel Umholtz (J).

Southern New England Section
Frederick J. Garbarino (M), Alfred B. Yard, Jr. (J).

Syracuse Section
David L. Moore (J), John Francis Murphy (J), William Joseph Skelley (J).

Applications Received

K. Pickard, William D. Pittsley, Clement W. Prestler, Edward Harold Protz, William George Roven, Charles M. Rubley, George J. Scranton, Ralph N. S. Scheidt, Harlan M. Splawn, Carl H. Turnquist, Thomas A. Wilkinson, H. O. Woods, Andrew F. Zupanc.

Hawaii Section
Joseph Chun Lee, Leonard O. Lister.

Indiana Section
Fred E. Boze, A. A. Catlin, Richard

W. Dickey, Milton L. Munson, Lt-Com. Herbert James Ward.

Metropolitan Section
Alfred Del Vecchio, Kachas Derdiarian, Hugh S. Kelly, George Albert Kern, Paul D. Mayr, Russell C. Mazer, Donald S. McArthur, Peter J. Schuessler, John Scribano, Nathan Winarsky.

Mid-Continent Section
Robert O. Gose.

Milwaukee Section
Charles Nash Miller.

Mohawk-Hudson Group
H. Clifford Brosey, Dwight C. Hannay, John H. Rogers, Eugene J. Walton, Jr.

New England Section
Charles Hurwitz, J. Conrad Johnson, W. Frank Morrissey.

Northern California Section
Alfred G. Anderson, Robert A. Coit, William Edward McComas, James Elwood Weesner.

Northwest Section
Richard M. Beauchamp, J. B. Dahl, Kenneth G. Fosnes, Jr., William D. Trenko.

Oregon Section
Newell T. Palmer, J. Gerrold Strauss.

Philadelphia Section
William Lucas Betts, Clarke Leigh Bicking, George Burnham Calkins, Daniel L. Pastell, William N. Richards, Paul J. Seng, Preston Lea Watson.

Pittsburgh Section
William W. Beck, J. Dick Blackburn, Joseph N. Kellerman.

Salt Lake City Group
Pete J. Visser.

San Diego Section
Raymond W. Anderson, Oliver B. Lyons.

Southern California Section
C. E. Deardorff, Norman A. Faber, Basil Dee Garrett, Robert Bruce Kelly, Thomas J. Myers, Richard C. Poucher, H. J. Schlarb, Win Ward, Charles F. Wingate.

Texas Section
John J. Kropp.

Virginia Section
Archie L. Grinels, John A. Mahrley, Emerson L. Thomas.

Washington Section
William Henry Irick.

Western Michigan Section
John M. O'Brien, Frank P. Schmitt, Guy L. Stevens.

Williamsport Group
Chester L. McGarr.

Outside of Section Territory
Paul W. Husby, Harry A. Johnson, Carleton F. Maylott, George T. Powell, Jr., P. J. T. Rawlins, John Robert Taylor.

Foreign
Paul Wilhelm Aberg, Sweden; Sergio Goldenberg, Chile; Nils Henry Borje Kristenson, Sweden; George James Bennett Mayo, England; Ramakrishna Ponneri, England; Karl Stief, Germany; S. Vijayaraghavan, India.
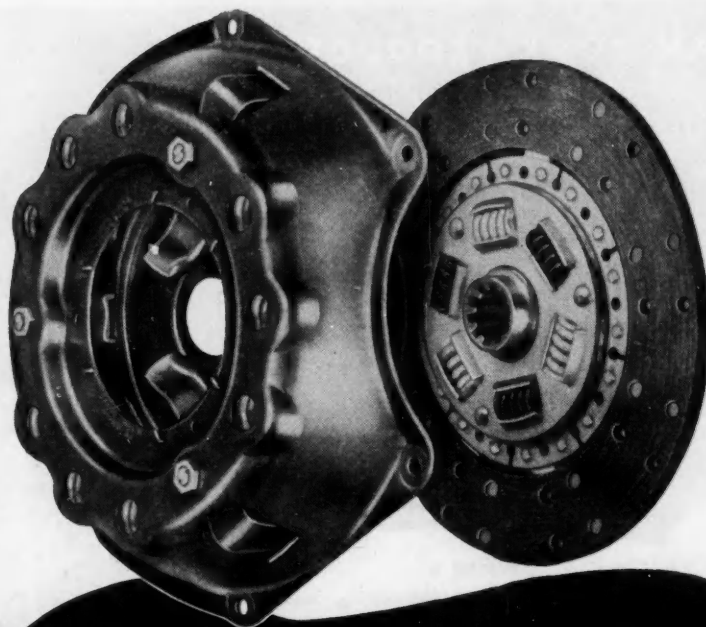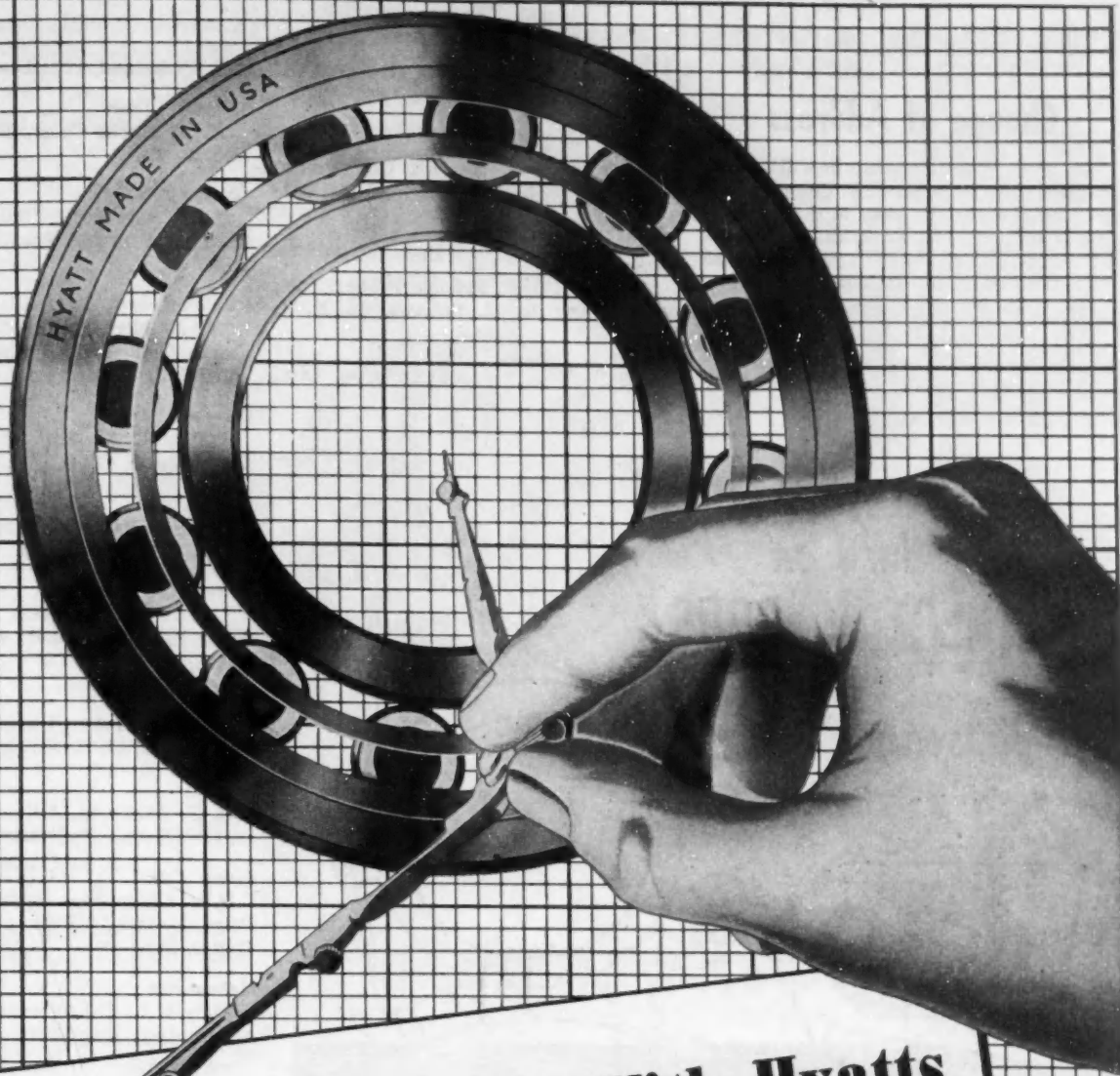
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1. Society of Automotive Engineers, Inc., 29 West 39th St., New York 18, N. Y.
2. The Secretary or Assistant Secretary of your Section or Group at the addresses listed below:

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R. D. Taber, Koppers Co., Piston Ring Div., Bush & Hamburg Sts., Baltimore 3, Md.

Buffalo
Robert D. Best, Fredric Flader, Inc., 583 Division St., N. Tonawanda, N. Y.

Canadian
C. E. Phillips, Perfect Circle Co., Ltd., 175 Wicksteed Ave., Leaside, Ont., Can.

Central Illinois
K. J. Fleck, Caterpillar Tractor Co., Peoria, Ill.

Chicago
T. A. Scherger, Studebaker Corp., Main & Bronson Sts., South Bend 27, Ind.

Cincinnati
W. A. Kimsey, R. K. LeBlond Machine Tool Co., Madison Ave. & Edward Rd., Cincinnati 8, Ohio

Cleveland
(Miss) C. M. Hill, 7016 Euclid Ave., Cleveland 3, Ohio

Dayton
R. S. Goebel, Production Control Units, 901 Shroyer Rd., Dayton 9, Ohio

Detroit
(Mrs.) S. J. Duvall, Detroit Office, SAE, 100 Farnsworth Ave., Detroit 2, Mich.

Hawaii
E. G. McKibben, Pineapple Res. Inst., P.O. Box 3166, Honolulu 2, T. H.

Indiana
R. P. Atkinson, Allison Div., General Motors Corp., Indianapolis, Ind.

Kansas City
F. V. Olney, Gas Service Co., Kansas City Mo. Div., 842 Grand Ave., Kansas City 6, Mo.

Metropolitan
(Miss) J. A. McCormick, Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y.

Mid-Continent
W. K. Randall, Carter Oil Co., P.O. Box 801, Tulsa, Okla.

Milwaukee
H. M. Wiles, Waukesha Motor Co., Waukesha, Wis.

New England
W. F. Hagenloch, Lenk, Inc., 1305 Boylston St., Boston 15, Mass.

Northern California
H. M. Hirvo, Enterprise Eng. & Fdy. Co., 600 Florida St., San Francisco 10, Calif.

Northwest
C. F. Naylor, Ethyl Corp., 1411 Fourth Ave., Seattle, Wash.

Oregon
Ray Mobley, Wentworth & Irwin, Inc., 1005 W. Burnside, Portland 9, Ore.

Philadelphia
Laurence Cooper, Autocar Co., Lancaster Ave., Ardmore, Pa.

Pittsburgh
J. E. Taylor, Gulf Research & Development Co., P. O. Drawer 2038, Pittsburgh 8, Pa.

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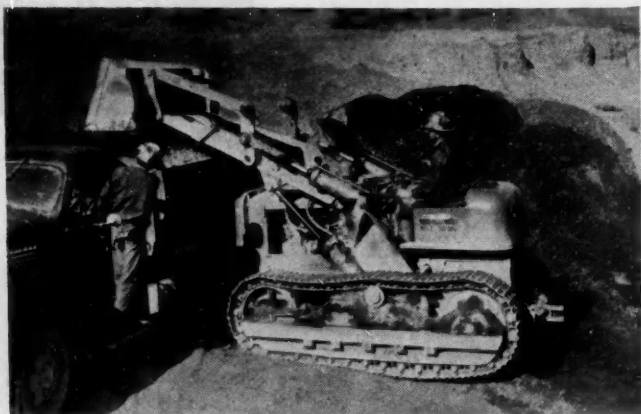
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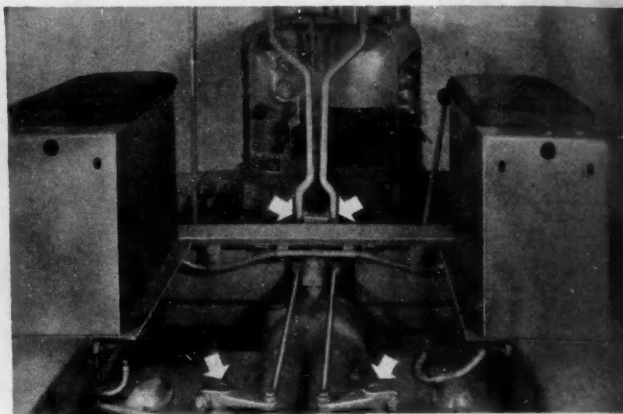
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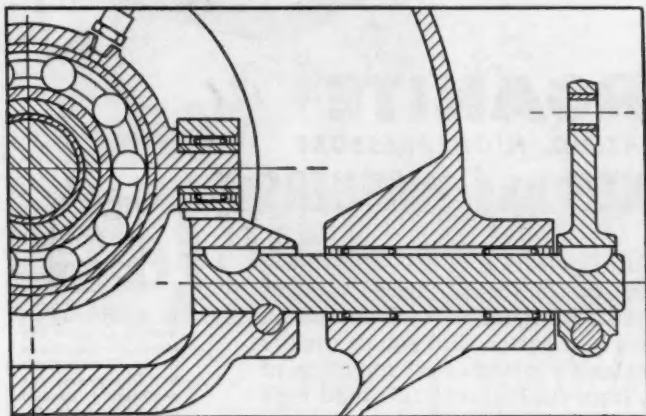

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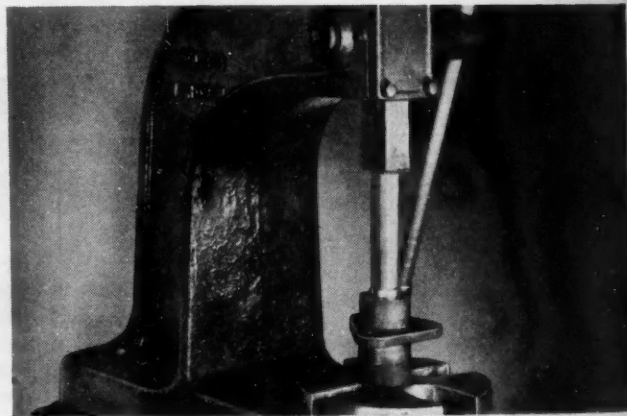
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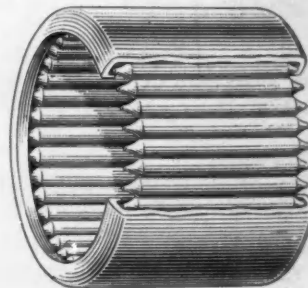
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